5 Management Plan Objectives and Methods: 2007-2017

5.1 Land Protection

5.1.1 Land Acquisition

5.1.1.1 1985-2006 Land Acquisition Program

The three active Division watersheds have been included in the land acquisition program since its inception in 1985. While a preponderance of the available acquisition resources have been used to acquire acreage on the Wachusett Reservoir watershed (highest priority), sensitive lands have also been protected on the Quabbin Reservoir and Ware River watersheds. The purpose of the land acquisition program is to acquire sensitive watershed land and to protect it from urbanization and then to restore and/or maintain stable forest cover on this land. Few sites already developed or significantly disturbed are acquired. Instead, relatively undisturbed lands are purchased as a preventative measure, countering potential threats to water quality that would result from development of these lands.

To help determine which parcels would provide the greatest water quality protection for the money spent, the former MDC/DWM developed land acquisition models, first for the Wachusett and then, in 1998, the Ware River watershed. Land in and around tributaries, aquifers, and wetlands will contain the greatest proportion of a basin's water at any given time. Studies of small New England watersheds emphasize the importance of low lying, water-rich areas in contributing the majority of runoff during storm events through saturated surface and subsurface flow (Dunne and Leopold, 1978, and Hewlett and Nutter, 1969). As a precipitation event continues, the area contributing to saturated flow increases. It is believed that this "variable source," however severe the storm event, includes less than half the watershed area. Pollutants introduced to these water-rich sources are more likely to impact tributary water quality than those introduced on non-source areas.

Land Protection Highlights:

1. The Commonwealth, from 1995 to 2004, has acquired 368 acres for watershed protection on the Quabbin watershed, bringing the total holdings to 54,311 acres.
2. **Payments in lieu of taxes** for Quabbin watershed towns are approaching $1.8 million/yr
3. DWSP **technical assistance to landowners and communities** aids watershed protection efforts. Since 1995, 5,323 acres of private forestland were enrolled in Stewardship via $63,058 of DWSP funding, about $1/acre/yr.
4. The 160 miles of **boundary** associated with the DWSP Quabbin holdings are maintained every 10 years. The 289 acres of utility rights-of-way are subject to site-specific controls and utilities are required to submit 5-year and yearly plans for their management.
5. Seven **Watershed** Rangers are assigned to Quabbin/Ware River and tasked with rules education and pro-active surveillance patrols, as well as emergency response for both legal and illegal access to the DWSP properties. Domestic animal and human trespass are the most common interventions.
6. **Wildfires** occur 2-3 times per year at Quabbin and are generally held to less than 10 acres in size. The local Fire Chief directs DWSP crews, who have received regular training in fire control. Fire fighting equipment upgrades and maintenance of access roads provide further improvement in Division fire response.
7. **Watershed security** received additional focus after the events of September 11, 2001 and the Bioterrorism Act of 2002 required Vulnerability Assessments, delivered for Quabbin in September 2003. Among the changes are the closing of sensitive access points, background checks for research permits, better gate management, among many others.

Protecting large tracts of land in a small state like Massachusetts is not easy. Massachusetts has the third highest population density in the country and developmental pressures and competing uses for open space areas are high. The biggest threat to biodiversity in Massachusetts is fragmentation of habitat caused by development. Land conservation is an important tool in dealing with water conservation, biodiversity and habitat protection, and open space fragmentation.

Unlike the Wachusett and Ware River watersheds, the Quabbin watershed has not yet been modeled to determine land protection priorities. DCR control of Quabbin watershed acreage stands at 56.9% - much higher than the other active watersheds. Rather, Quabbin subwatersheds have been prioritized for land protection decision making. **Table 34** shows these subwatersheds and their current protection levels for both DCR lands and other protected open space.

Table 34: Open Space Protection in Quabbin Basins with Acquisition Opportunities

Subwatershed	Total Acres	Total Open Space	DCR Controlled	Other Open Space	% Protected
West Branch of Swift River	14,845	10,427	9,012	1,415	70.2
Fever/Hop Brooks	21,158	15,110	12,986	2,124	71.4
East & Middle Branches of Swift River	34,761	13,220	6,977	6,243	38.1
TOTAL	**70,764**	**38,757**	**28,975**	**9,782**	**54.8**

Source: DCR/DWSP, 2007

From 1995 to 2004, the Commonwealth has acquired, for watershed protection, 368 acres on the Quabbin watershed, bringing the total holdings to 54,311 acres, or 56.9% (up from 54.3% in 1985) of the watershed. Expenditures for this acreage total $1.292 million. Funding for the watershed land acquisition program since 1985 has come from the 1983 Open Space Bond ($3 million); the 1987 Open Space Bond ($30 million); and the Watershed Protection Act of 1992 ($135 million).

As DCR/DWSP pursues new land acquisition funding options, DWSP will concentrate on purchasing land on the Wachusett watershed, which is the least protected basin, with 26% under Division control. Efforts will continue, however, toward purchasing a number of previously identified key parcels throughout the Quabbin Reservoir and Ware River watersheds.

5.1.1.2 Future Land Acquisition Objectives

Future land acquisition in the Quabbin Reservoir watershed is expected to be limited and very selective, given the expected available funding and the fact that much of the watershed is already protected lands. Particular emphasis will be given to projects that address the acquisition of inholdings in order to consolidate boundaries, and conservation restrictions on prioritized parcels that, when protected, will prevent adverse changes in land use considered a significant threat to water quality by the Land Acquisition Panel (LAP). Gifts, bargain sales, and partnering opportunities in land acquisition will contribute to a more favorable prioritization status.

The Quabbin watershed is divided into three priority zones for land protection, based on travel time data (pollutant fates), and proximity to aqueduct intakes. The primary zone is the West Branch of the Swift River. The secondary zone is the Hop Brook, Fever Brook, and Middle Branch tributaries. Tertiary status is given to the East Branch of the Swift River.

5.1.1.3 Payments In-Lieu of Taxes (PILOT) Program

5.1.1.3.1 PILOT Program Description and Legislation

The DCR Division of Water Supply Protection, Office of Watershed Management PILOT program annually monetarily compensates the communities that contain the land and water bodies that comprise one of the nation's largest unfiltered water supply systems. The Payment in Lieu of Taxes program guarantees regular and stable payment to 31 communities (see **Table 35** for the 11 towns within the Quabbin Reservoir watershed).

The PILOT program is mandated by Massachusetts General Laws ch. 59, § 5G . This legislation updated old payment laws MGL ch. 59, §§ 5D-5F, which were written in the 1940s, and did not value lands in all communities currently entitled to payments. The current PILOT law was first ratified in 1984 for the Quabbin Reservoir and Ware River watersheds. The law was amended in 1987 to include communities in the Wachusett Reservoir and Sudbury Reservoir watersheds.

5.1.1.3.2 PILOT Funding

Money for the Office of Watershed Management PILOT program comes from the Massachusetts Water Resources Authority (MWRA) rate payers who use the reservoir waters. They pay their water bills to the MWRA, which provides DCR with the funds needed to make the PILOT payment. DCR makes the annual payment in full to each community in the program. This program is solely for lands managed for drinking water supply by the Office of Watershed Management. All other state-owned lands that are eligible for payments in lieu of taxes under MGL ch. 58, §§ 13-17 are reimbursed, subject to appropriation, by the legislature through state aid to municipalities (the "cherry sheet").

5.1.1.3.3 PILOT Amounts

The Department of Revenue (DOR) revalues state-owned land every four years. The most recent DOR revaluation assessed all property owned in-fee by the Commonwealth as of 1/1/2005. The revaluation takes into account all lands purchased by the state over the previous five years as well as any changes in land values. The new values took effect in FY2006.

The PILOT amount is determined by multiplying the Department of Revenue valuation of DCR Division of Water Supply Protection land by the highest local property tax classification (regardless of actual land classification). Most PILOT land is forested, but the PILOT calculations use the same rate structure as commercial or industrial property. Legislative provisions state that the Office of Watershed Management PILOT payment can never be less than that of the previous year, even if the value of the land or tax rates decrease.

DCR works diligently with the watershed communities, MWRA, and DOR to comply with the PILOT law. **Table 35** demonstrates that the PILOT program provides substantial revenue to the watershed communities. MGL ch. 59, § 5G also dictates that five Quabbin Reservoir watershed communities (Belchertown, Hardwick, New Salem, Pelham, Petersham and Ware) receive a second payment for lands annexed from the disincorporation of the former towns of Dana, Enfield, Greenwich, and Prescott. The amount received from this second payment totaled $429,360 in FY2007, representing 31% of the total PILOT received by these five towns. The 2007 "Independent State Auditor's Report on the Department of Conservation and Recreation and the Massachusetts Water Resources Authority Compliance with Watershed Agreement Requirements" (Commonwealth of Massachusetts, Auditor of the Commonwealth, No. 2007-0276-3C, Boston, MA August 2007) specifically noted that "there is no apparent reason for making PILOT payments twice for the same piece of land," however any change in this payment process will require legislative action. Legislation was proposed in January 2007; however at the time of publication no final action has occurred to amend the PILOT law.

Table 35: Payment-in-lieu of Taxes FY05-FY06, Quabbin Reservoir Watershed Communities

Community	PILOT FY2005	PILOT FY2006	% TOTAL PILOT+
Barre	$129,668	$129,668	2.2%
Belchertown*	$170,786	$171,883	2.9%
Hardwick*	$54,761	$54,761	0.9%
New Salem*	$264,481	$264,481	4.5%
Orange	$3,286	$3,286	0.1%
Pelham*	$162,276	$186,864	3.2%
Petersham*	$338,978	$338,978	5.7%
Phillipston	$7,067	$7,067	0.1%
Shutesbury	$250,019	$250,019	4.2%
Ware*	$320,224	$320,224	5.4%
Wendell	$16,247	$16,247	0.3%
Total Quabbin Watershed	**$1,717,793**	**$1,743,478**	29.5%
Total PILOT+	**$5,076,573**	**$5,919,709**	

Source: (DCR/DWSP, 2006)

* Includes payments for land annexed by town after disincorporation of communities for Quabbin Reservoir.

\+ Distributed to 31 communities in the Quabbin Reservoir, Ware River, Wachusett Reservoir, and Sudbury Reservoir Watershed Systems

5.1.1.4 Land Disposition Policy

DWSP regularly comes under pressure from both private and municipal parties for disposition of parcels of its lands for purposes that may be inconsistent with drinking water supply protection. While there are certain areas of land ownership throughout the water supply system that may not be of critical importance to water supply protection, these areas require careful scrutiny prior to disposition. DWSP will consider land disposition only under exceptional circumstances for private or municipal uses. DWSP will not promote the use of watershed lands for purposes that are inconsistent with goals for water quality protection. The proponent of the disposition must demonstrate that resources of greater value will be protected either through acquisition of Article 97 land or through other means, so that the missions and legal mandates of DWSP are protected and enhanced.

The Watershed Land Disposition Policy, approved in April, 1998, provides a framework for the agency to properly discharge its obligations to protect the water supply and to protect the Commonwealth's broader interests in open space protection under Article 97 of the Constitution of the Commonwealth. The intent of the policy is to provide additional watershed-specific instructions to the Executive Office of Energy and Environmental Affairs on disposition of Article 97 lands. DWSP follows EOEEA's land disposition guidelines and DWSP is extremely stringent about agreeing to land dispositions and will pursue them only if the disposition can be a benefit to the Commonwealth and the protection of our water resources.

Disposition Procedures

1. All reviews of Article 97 land disposition requests by DCR/DWSP shall be consistent with *EOEEA Article 97 Land Disposition Policy*.

2. A written request shall be submitted to DCR/DWSP for disposition of a particular parcel.

3. If the disposition request is proposed by a municipality, it shall appoint a committee to initiate the DCR/DWSP review process.

4. DCR/DWSP shall provide copies of EOEEA and DCR/DWSP Article 97 land disposition policies to the proponent and, if applicable, to members of the municipality's appointed committee.

5. The proponent shall submit an EOEEA-approved Open Space and Recreation Plan (M.G.L. c.41 §81D) to DCR/DWSP.

6. Alternatives to disposition of the Article 97 land shall be evaluated for prioritization based on their impact on the water supply, criteria provided by DCR/DWSP and the municipal committee, and local interests. DCR/DWSP staff may provide guidance to the municipal committee, if possible.

7. The proponent shall comply with the requirements of the Massachusetts Environmental Policy Act (MEPA) as it relates to disposition of Article 97 land. This includes requirements for disposition of parcels of two acres or more, and those proposed uses which would have significant traffic impacts (M.G.L. c.30 §61-62).

8. The proponent shall comply with all applicable state and federal laws and regulations, including the state and federal Rare and Endangered Species acts (M.G.L. c.131A, 16 U.S.C. §1531), Historic Preservation Acts (M.G.L. c.9 §§26-27C), Wetlands and Rivers Protection Acts (M.G.L. c.131 §40, 33 U.S.C. §1251, et.seq.).

9. The proponent shall demonstrate that resources of equal or greater size, resource value, and fair market value will be protected, as determined by DCR/DWSP and EOEEA, either through acquisition of additional Article 97 land or through other means, so that the missions and legal mandates of DCR/DWSP and EOEEA are protected and enhanced. Any disposition may affect future Payments In Lieu of Taxes (PILOT) to a municipality.

10. Upon receipt of all relevant documentation, DCR/DWSP shall review the disposition request. If approved, the request shall be forwarded to the DCR Lands Committee and the DCR Commissioner. The Commissioner has the jurisdiction over the disposition of DCR/DWSP managed lands, and has the authority to approve or overrule the recommendation of DCR/DWSP.

11. Following approval by the DCR Lands Committee and the Commissioner, the disposition request shall be sent to the Secretary of EOEEA and the Commissioner of the Massachusetts Division of Capital Asset Management (DCAM) for their approval.

12. Following approval by all required state agencies, the proponent shall provide a registered survey plan, including the metes and bounds of the parcel.

13. Any disposition, whether by lease or fee, shall include language which causes the land to revert to the Commonwealth if the land is not used for the approved purpose or the proponent does not adhere to the terms and conditions of the disposition agreed to by the proponent and DCR/DWSP. Any disposition shall include transfer of land of equal or greater size, resource value, and fair market value. If a disposition involves replacement real estate land of lower fair market value, the difference in fair market value between the replacement parcel and the subject parcel must be paid to the DCR Water Supply Protection Trust.

14. The proponent shall identify a legislative sponsor who shall submit Article 97 land disposition legislation for approval by the General Court.

5.1.2 Protection of Private and Community-Owned Lands

5.1.2.1 Conservation Restrictions

In addition to direct land acquisition, DCR/DWSP has been protecting land within the watersheds by using cost effective conservation restrictions to protect land from development while simultaneously encouraging private landowners to continue to practice effective stewardship on their properties.

A conservation restriction (CR, also called a conservation easement) is a legal agreement a property owner makes to restrict the type and amount of development that may take place on his/her property. A property owner agrees to sell or donate limited rights to their property to a state agency or nonprofit land conservation agency. The landowner remains the owner and retains all rights to ownership except those described in the conservation restriction.

There are both conservation and monetary advantages to landowners who sell or donate CRs. Neither landowners nor the purchasing organization/agency of a CR can develop the land in ways prohibited by the deed. Furthermore, landowners are paid not to develop their property. After the sale of a CR, the property is assessed at a lower value due to its development restrictions, which in turn reduces the landowner's property taxes and possibly estate taxes as well. If the CR is donated for conservation purposes, it also generates an income tax deduction. Consultation with a qualified estate planner is strongly recommended by DWSP so that landowners clearly understand the specific benefits of a CR on their property.

Once recorded, a CR remains in effect for future owners should the landowner decide to sell the property. Future owners are bound by the restrictions within the CR. CRs are usually permanent and in order for a CR to qualify as a tax-deductible charitable gift, it must be granted in perpetuity. A popular alternative to putting an owner's entire property under restrictions is to work with the acquiring agency to survey the area to be placed under the CR, while excluding any area that the owner wants to remain unrestricted. Often the owner's house and outbuildings will be excluded from the CR.

DCR/DWSP pursues the acquisition of CRs as well as fee acquisitions for the purpose of water and watershed protection. There is no PILOT obligation to DCR from a CR because the land remains as private property. Each CR is tailored to the interests of the owner and DCR. It is the policy of DCR/DWSP to purchase CRs that will not conflict with water quality protection. Typical use restrictions include construction of buildings or utilities, septic systems, paving, dumping, excavating, mining, use of pesticides, storing hazardous materials, and certain agricultural purposes. Continued use of the property by its owners for forestry, wildlife, recreation and privacy purposes is encouraged.

Once DCR/DWSP purchases a CR, it assumes the responsibility for conducting a baseline survey of existing conditions. A staff person will photo-document the entire property, prepare maps and gather as much information about the property from the owner as possible. It is very important to document what uses were in effect at the time of the acquisition. Permissible uses are also generally transferred with new ownership when CR property is sold. In the spirit of conservation, DWSP will require that any items that may be inconsistent with the provisions of the CR be removed when land owners are able, such as junk cars, appliances, or other waste debris. A yearly inspection is conducted to ensure that the purposes of the CR are being maintained. DCR/DWSP will work with a landowner to help prevent negative impacts, such as abutter encroachments and unauthorized recreational access, and will also help provide technical assistance for managing these lands.

DCR/DWSP currently holds 54 CRs across the Quabbin, Ware River, and Wachusett watersheds. These CRs total 3,533 protected acres. Most CR owners are individuals. However DCR has also purchased CRs from sportsman's clubs, golf courses, and municipalities. There are 10 DWSP CRs, totaling 715 acres on the Quabbin Watershed.

5.1.2.2 Technical Assistance to Communities

In the Commonwealth of Massachusetts, municipalities have significant authority over land use and development. Towns are authorized to enact and enforce a variety of statutes, including zoning bylaws, subdivision bylaws, and overlay districts (such as aquifer protection bylaws). In addition, the state delegated partial authority for regulations such as Title 5 and the Wetlands Protection Act to municipal governments.

Volunteer boards, such as the local boards of health, conservation commissions, and planning boards, are responsible for these bylaws and regulations. Tasks that board members must perform include reviewing proposals, determining if the applicable standards are met, issuing approvals or permits, and supervising construction and other on-site compliance reviews. In many towns, especially small ones, there are few paid professional positions, and the boards may not have town staff to support them. Further, the board members may or may not have received training in that technical area. DWSP's community technical assistance program seeks to maximize the watershed protection afforded under locally delegated controls by offering its expertise and resources to support local officials' decision making.

DWSP historically has maintained contact with local boards through the review of major development proposals, construction site inspections, and other situations pertaining to compliance with state and federal regulations. Through these efforts, the agency has helped to address a range of water supply pollution sources, such as septic systems, sedimentation from construction, road drainage, stormwater runoff from residential area, and recreational field runoff. DWSP's involvement in local planning and environmental issues was greatly expanded with the passage of the 1992 Watershed Protection Act (WsPA). The WsPA specifically required a program of technical assistance to affected communities that includes, but is not limited to, "planning studies, and zoning bylaw studies, health bylaw studies and subdivision by-law studies" (Chapter 36 of the Acts of 1992, §15: regulations included in **Appendix II**).

The DWSP Technical Assistance Program encompasses the following types of activities:

1. Growth management planning, master plans, and land use studies.
2. Review, revision, and development of by-laws, subdivision and other regulations, protective districts, and performance standards.
3. Refinement of local monitoring, review, permitting, and enforcement practices.
4. Design advice to municipal boards or landowners from natural resource, engineering, and planning professionals.
5. On-site reviews of proposed development projects with local board members and municipal officials.
6. Public education programs.
7. Applied watershed management research.
8. Technology transfer.
9. Coordinating program topics and audiences with other technical assistance organizations (such as watershed associations).

The Technical Assistance Program provides the watershed communities three different avenues to obtain help with their local land use regulatory needs:

1. **Board Communication:** Attendance at local board meetings is an effective way to foster good communication between DWSP and the watershed communities. DWSP presence offers both regulatory review and the opportunity to provide immediate technical assistance and, if need be, the recommendation for more in-depth consultation.

2. **In-House Projects:** There are some instances where a town requires more than a conversation to help with a project. In cases where DWSP staff have time and resources, the agency provides in-

house support. Projects that the Quabbin Environmental Planning staff have worked on are included as **Appendix V.**

3. **Technical Assistance Contracts:** There are many land use planning projects that communities want to initiate that are beyond their financial means. Throughout the 1990s, DWSP, upon the request of a watershed town, would support a study or plan if finances were available. A critique of these efforts was that the funds were distributed on a first-come, first-serve basis and that some towns were not obtaining this financial support. The 1998 Watershed Protection Plan for Wachusett Reservoir and the 2000 Watershed Protection Plan for Quabbin Reservoir identified the need for a competitive program to distribute Technical Assistance contracts. Staff established a process that was implemented in FY2002, distributing over $150,000 throughout the watershed system, including funding for Master Plans in Petersham and Shutesbury, as well as septic system site analyses in New Salem and Wendell. Unfortunately these funds were a casualty of subsequent budget restrictions. A relatively small amount of funding ($16,000) was identified in FY2007 and was used to provide reference materials and training opportunities to town Planning Boards, Conservation Commissions, Building Inspectors, Zoning Boards of Appeals, and Boards of Health. Due to the success of this initiative, the Division will continue to utilize these funds, when available, for efforts that further support the work of local boards in their creation, interpretation, and implementation of laws that promote water quality protection.

By working with watershed area officials and citizens, DWSP can successfully find common ground on resource protection issues. These projects help both local resources and the Metropolitan Boston water supply. The technical assistance program emphasizes local source protection and its immediate impact to watershed residents and decision-makers. Through this cooperative approach, DWSP improves the land-use planning, control of development, and general environmental protection at the local level, which ultimately benefits drinking water source protection. It is, however, the town's responsibility to adopt and implement any plan or bylaw.

5.1.2.3 Technical Assistance to Private Forest Landowners

In 1994, private forest lands on the Quabbin and Wachusett Reservoir watersheds and the Ware River watershed totaled in excess of 95,000 acres. In 1995, DWSP started its Private Lands Forestry Program to provide funding for private forestland owners to complete 10-year management plans for these forests, in an effort to forestall development of these parcels. Letters were sent to private consulting foresters informing them that clients whose properties fell within the water supply watersheds were eligible for 100% funding of the cost of producing management plans, using current requirements of the Forest Stewardship Program in order to secure Chapter 61 property tax abatement if they desired, or to access incentive funds available for practices.

Over the course of the 12 years that the program has functioned, the agency has provided $63,058, with which we have enrolled a total of 5,323 acres in Stewardship and/or Chapter 61 for ten-year periods, at an average cost of $12 per acre (or just over $1 per acre per year). This acreage is divided among 71 parcels, with an average parcel size of 75 acres. **Table 36** shows how these acres are distributed by watershed.

Table 36: Private Lands Forestry Assistance

Watershed	# of Parcels	# of Acres	Average Parcel Size	Total Cost
Quabbin	22	2,170	99	$25,697
Wachusett	35	2,275	65	$26,908
Ware River	14	879	63	$10,453
TOTAL	**71**	**5,323**	**75**	**$63,058**

The Executive Office of Energy and Environmental Affairs identified this type of program as critical to

long-term protection of the Massachusetts landscape, and has subsequently dedicated funding to a comprehensive, statewide private forest lands program through the Massachusetts Forest Stewardship Program. To avoid redundancy, DWSP has suspended its own private lands assistance program.

5.1.3 Boundaries

The total length of the boundary that encompasses DCR/DWSP holdings surrounding the Quabbin Reservoir is 160 miles, of which 4 miles abut private in-holdings and 8 miles abut the Shutesbury State Park in-holding. DWSP property boundaries are the "front line" of watershed protection, in that they are immediately adjacent to private land on which DWSP's watershed protection principles may or may not be followed. The protection provided by boundaries is therefore enhanced by regular maintenance to keep them visible, and by immediate identification and resolution of encroachments.

5.1.3.1 Maintenance of Boundaries

Maintenance of DWSP boundaries is a straightforward but daunting task. Before maintaining boundaries, DWSP engineering and forestry staff must first determine their exact location in the field, accounting for recent land acquisition and its effects on the adjacent and outermost boundaries. Once accurately relocated, these boundaries are kept visible by the forestry staff on a regular 10 year cycle, primarily by clearing brush along the line and repainting blazes. This regular perambulation of the boundaries also serves to identify encroachments (see Section 5.1.3.2).

5.1.3.2 Encroachment Discovery and Response

Encroachment by abutters onto the Commonwealth's properties has become a significant problem across DCR watersheds. This is due in part to development pressures, occasional unclear boundaries and a lack of monitoring and enforcement. Some of these encroachments are minor (e.g., mowing onto Commonwealth property), while others are quite significant (e.g., re-grading, landscaping, or placing structures directly on DCR property).

Most encroachments are discovered by field staff (civil engineers and foresters) while performing routine boundary marking or surveying of areas where boundary lines are unclear. Once an encroachment is identified, a series of letters and field inspections are required in order to ensure compliance with the actions recommended by DWSP. Through experience, the Division has determined that the best method for preventing new encroachments is by swift, effective, and fair resolution of those that are discovered. A small number of encroachments need to be resolved through court actions that require a great deal of additional police and DWSP staff time. DWSP strives whenever possible to resolve encroachments outside of the court.

5.1.3.3 Cooperation with Abutters

Division staff work hard to educate abutters about the agency's objectives for watershed protection. As the largest landowner within the Quabbin watershed, it is extremely important for the Division to maintain a good relationship with abutters to DWSP property. Setting a good example of proper land stewardship for neighboring property owners may positively influence an owner's actions on their own property. By having a good relationship with abutters, it is more likely that neighboring landowners would report unauthorized uses or encroachment problems that may occur on DWSP land.

Section 42 of Chapter 132 of Massachusetts General Laws, also known as the Forest Cutting Practices Act, includes the following requirement for notification of abutters:

> Every owner of land who proposes to cut forest products on land devoted to forest purposes, or to cause such products to be cut, except as provided in section forty-four, shall send by certified mail or hand deliver written notice of his intention to begin any cutting operation to the abutters of record on file with the assessors of the town in which

the land lies, and whose closest boundary is within two hundred feet of the edge of the cutting area, at least ten days prior to operations

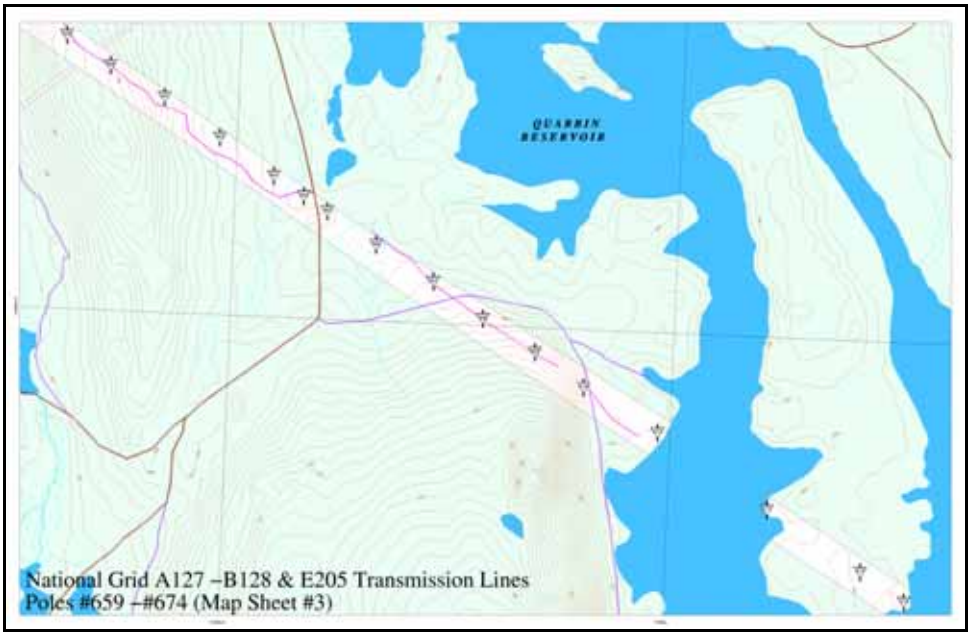
The majority of the DWSP properties at Quabbin are greater than 200 feet from adjacent, privately-held lands, so that notification is not required. However, the Division does notify abutters when harvesting on portions of the property that abut within 200 feet.

5.1.3.4 Rights-of-Way

DCR maintains site-specific watershed protection controls within the approximately 289 acres of rights-of-way (ROW) of utilities, railways, and highways crossing the Quabbin Reservoir Watershed. These controls are designed to minimize risks to water quality associated with the maintenance and use of these corridors in the watershed. Power line ROW are typically vegetated and maintained in a constant state of early succession to prevent contact with the wires, which could cause possible disruption of service*. In order to conduct this maintenance, utilities in Massachusetts are directed by 333 CMR 11.00, Rights-of-Way regulations administered by the Massachusetts Department of Agricultural Resources, to develop and submit for approval five year, Vegetative Management Plans (VMP) and Yearly Operational Plans (YOP).

As part of the approval process, DCR specifically reviews and comments on the planned activities to apply herbicides to control vegetation†. Resource identification (public surface water supplies) and associated "no spray" and limited zone delineation on maps and in the field is the focus on this review. A sample "T-sheet" that identifies the power line ROW in relation to the water resource appears below (**Figure 13**). These maps were developed by DCR staff to aid in the YOP review process prior to field visits. Monitoring is primarily targeted at buffer zone maintenance documentation and reporting. Over the past five years, DCR staff have also been contributing to the update of 333 CMR 11.00. The final version of these regulations was adopted in March, 2007.

Figure 13: Sample "T-sheet" for Powerline ROW



* Powerlines in the eastern US have been found to constitute a potential reservoir of shrubland habitat for birds species that breed in early-successional shrubland habitats (King, 2002).
† Review was also conducted under 1997 MOU between DAR and MDC. This MOU was revoked by DAR on 12/6/06.

5.1.4 Public Education

5.1.4.1 Role of DWSP Watershed Rangers in Land Protection

The Division controls about 42% of a 257,000-acre watershed and reservoir system, which provides drinking water for nearly 2.2 million people. Public access to this system is determined by regulation and policy. Physical barriers such as gates help to prevent inappropriate uses throughout the watershed. For several decades prior to 1992, the Metropolitan Police, who had jurisdiction in any town that contained Division property, patrolled the watershed system. In 1992, the Metropolitan Police force was consolidated with the State Police and local police departments. A Memorandum of Understanding was established with the MA State Police to provide the same services to the Division watersheds that were carried out by the former Metropolitan Police. Following the consolidation, the MDC felt it would be prudent to create a limited ranger program to complement the efforts of the MA police, including rangers specifically assigned to watershed protection. MGL Ch. 92, s. 34b specifies the authority of these rangers:

> The Metropolitan District Commission is hereby authorized to establish a park ranger program within the department to preserve, maintain and protect the parks, reservations, historic sites and open space and to ensure the environmental integrity of properties under the care, custody and control of the commission.

Within the Mission Statement of DCR Park Ranger Unit (which includes Watershed Rangers), four primary objectives are identified:

1. Resource Protection: Park Rangers will provide active and visible uniformed patrols of DCR properties and facilities in an effort to discourage improper use and criminal activity. Park Rangers issue verbal or written warnings and non-criminal citations to individuals who violate DCR Rules and Regulations and contact the MA State Police to address criminal activity.
2. Visitor Services: Park Rangers will assist visitors to DCR properties by providing them with information as requested, rendering emergency service when necessary, and promoting educational and recreational opportunities through various programs and activities.
3. Education and Community Relations: Park Rangers will encourage appreciation and proper use of DCR resources through various outreach programs. This includes maintaining an active working relationship with park visitors, user/friends groups and the owners of private properties abutting DCR lands.
4. Reservation and Historic Site Management: Park Rangers will assist in proper maintenance and protection of properties and facilities by implementing measures for damage prevention, conducting routine on-site inspections, promptly reporting and documenting maintenance problems, and taking and documenting corrective action.

The primary function of the Division's Watershed Rangers is to protect drinking water resources by conducting regularly-scheduled patrols of the watersheds. Watershed Rangers provide a visual, uniformed presence on Division lands and pro-actively patrol to help prevent problems, such as vandalism, inappropriate recreation uses, illegal dumping and accidents within the watershed that may degrade water, forest, wildlife and/or cultural resources. The Rangers rely on rules education rather than enforcement to seek compliance. Rangers do not have law enforcement powers. When situations occur that require law enforcement personnel, Watershed Rangers communicate these to the State Police and other enforcement agencies. In addition, the MA Environmental Police provide rules enforcement for complementary state wide environmental regulations. Watershed Rangers are in radio contact with both the EPOs and State police and meet systematically with both these groups. These relationships are critical to the enforcement of DCR regulations.

Since 1999, DCR Watershed Rangers have kept records of their access rule enforcement interventions. **Table 37** shows the total rules interventions by type from 1999-2005.

Watershed Rangers are "good will ambassadors" and not only show a positive presence but also speak on behalf of the agency and the Division about proper watershed stewardship and drinking water protection to community or other organization gatherings, children, school groups, service organizations, senior groups, etc. Through their positive interaction with visitors, rangers protect these open spaces and encourage all people to do the same by obeying all watershed rules and regulations for specific Division reservoirs and the system as a whole.

Watershed Rangers provide security for Division facilities and other designated buildings, and regularly monitor potential trouble spots on the watershed. Special use and group permits may be checked by Rangers to ensure that permittees are in compliance with their permit. Rangers keep a daily log of their patrolling activities. Incidents are documented and are referred to the appropriate authorities. Rangers also aid in placement of signage on Division lands throughout the watershed, to assure the public has ample opportunity to become informed about access regulations.

Since 1996, the number of Rangers assigned to the Quabbin/Ware River watersheds has grown from one to seven. Ranger patrols include pro-active surveillance of DCR/DWSP-owned lands with emphasis on popular access locations around the Quabbin watershed. Rangers monitor and report on the condition of trails and signs, ice conditions, and illegal activities such as dumping of trash and debris, illegal vehicle use, fires, swimming, and removal of natural or cultural resources. In addition, Watershed Rangers are trained as emergency first responders and have undertaken ice rescue training.

Table 37: Quabbin Watershed Ranger Interventions, 1999-2005

Intervention Type	Number of Rule Interventions
Domestic Animals	919
Trespass	896
Bike/Sled/Ski	215
Swim/Wade	161
Boating	122
Fishing	98
Snowmobiles/ATV/M.V.	61
Cooking/Fires	51
Vandalism	47
Dumping/Littering	47
Alcohol	38
Metal Detecting	15
Permit Violations	15
Collecting	14
Firearms/Target Shooting	3
Disorderly Conduct	2
Harassment/Breach of Peace	3
Non-compliance	1
Feeding Wildlife	1
Parasailing/Aircraft Landing	2

Source: OWM Watershed Rangers, 2005

5.1.4.2 Interpreting Land Protection/Management Priorities

Public education is a vital component of the Division's watershed management and protection programs. The Division strives to directly communicate not only what the access rules and regulations are and why they are necessary, but also what the land protection and management priorities are and how and why these are implemented. To this end, different sections work on different fronts of public education and interpretative services. The Watershed Rangers speak informally with users while patrolling property. The Quabbin Visitor Center Staff conduct school programs for students within watershed communities, maintain the Quabbin Visitor Center and related programs. In addition, the Forestry and Natural Resources staffs regularly provide field tours to academic institutions from around the world who are interested in the application of watershed forest management principles on the Quabbin watershed.

5.1.5 Fire Protection

DCR DWSP is committed to protecting the watershed forest, as well as watershed visitors, from the impacts of forest fires. While light burns in forest areas without forest regeneration cause little harm, hotter fires, especially in areas with younger forests, can cause serious impacts including death of both understory and overstory trees and exposure of mineral soil over large areas, causing an increased potential for overland flow, erosion, and nutrient loading. Two fires in the 1950s at Quabbin (one north of Route 122 and one on the Prescott Peninsula) were of this nature, killing significant areas of understory and overstory vegetation. All fires can endanger the visiting public and adjacent landowners.

Forest fire frequency over the last decade has decreased to approximately 2 to 3 incidents per year and these have all been <10 acres in size. Nearly all recent wildfires at Quabbin have been caused by the visiting public and were associated with illegal campfires or improper disposal of smoking materials. DCR/DWSP has implemented the recommendations of the 1986 Forest and Wildlife Management Plan, including:

- Strictly enforcing the prohibition against landing of boats on islands and the shoreline of the reservoir.

- Eliminating all public access to the Reservation during times of extreme fire danger conditions.

Through increased education and enforcement efforts, DCR/DWSP has reduced the number of illegal boat landings. A water protection policy was initiated which set up designated landing areas with portable toilet facilities. This action resulted in less beaching of boats in unauthorized areas and allowed for much better control of the visiting public.

DCR DWSP did close the watershed to public access during a brief period in October, 1984 due to extreme fire danger conditions. In a March, 1994 meeting between the then DEM and MDC, it was agreed that during periods of extreme fire danger, the two agencies would cooperate to provide trained personnel to keep fire watch from the tower at Mt. Grace in Warwick State Park. This site provides an excellent view of Quabbin and is best situated for triangulation with the Pelham and Princeton towers. [The 2003 merger of MDC and DEM into DCR resulted in two forestry related sections within the same agency. DWSP's foresters are solely responsible for watershed management lands, while the Bureau of Forestry serves both public and private lands, including the oversight of fire control.]

Other recommendations of the 1986 Quabbin Forest and Wildlife Management Plan which have been implemented include:

- Improve cooperation with local fire departments.

- Improve forest road conditions in areas of poor access and high fire hazard and risk.

- Implement a fire watch during extreme fire situations.

Due to the decrease in incidents, increased cooperation with area fire personnel and the relatively wet fire seasons experienced over the last decade, the recommendation "Training of Division staff in fire suppression" has been modified to include training in the Incident Command System (ICS) and in hazardous materials spill and boom deployment. Hazardous spills pose a greater risk to the water supply and it has been determined that this is a better use of limited training time.

Since 1986, the Division has made measurable improvements in many of the above areas. A fire policy was drafted in 1987 and has been improved and updated as recently as June, 2006. This policy specifically outlines the steps necessary for suppression of wildfires on DCR lands.

Through constant communication with town fire departments and DCR's Bureau of Forestry fire control personnel, the Division has improved the coordination of fire suppression. Effective coordination with local fire departments is critical as the local Fire Chief is the person legally in charge of a fire fighting operation. DCR/DWSP's role is to assist the local fire department and to assume responsibility only at the direction of the local fire chief (usually for "mop up" operations). The addition of a radio system at Quabbin that is linked to DCR Bureau of Forestry fire control personnel has greatly improved communications during wildfires.

Extensive progress has been made in the repair and maintenance of the forest road system at Quabbin over the years. This has improved access to most areas of the watershed (see next section for detailed report on roads). The Division has also acquired fire fighting apparatus that improves its readiness in fighting fires.

During the management period from 2006-2015, DWSP will develop a communication plan that addresses the inter-operability of the DCR radio system with local and state agencies. This plan will be part of the larger emergency operations plan being developed for the section.

The DWSP will also finalize the Watershed Emergency Access Map that highlights road intersections, boat launching sites, and helipads. This map will be distributed to local and state Police, Fire, EMS, Underwater rescue, and hazmat units which may respond to an incident on the watershed.

5.1.6 Security and Emergency Planning

The terrorist attacks of September 11, 2001 forced all public water suppliers to focus their attention on the security of the water supply. Security of the water system must be comprehensive – source to tap – but flexible enough to adjust to a range of potential threat conditions. The Division's policies are periodically reviewed in order to achieve the goal of providing a safe and secure water supply system.

Following "9/11", the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Bioterrorism Act) was passed into Federal Law (PL 107-188). Section 401 of that act amended the Safe Drinking Water Act (SDWA) by adding section 1433(a), which requires all community public water systems (including military installations) serving 3,300 people or more to conduct Vulnerability Assessments (VAs), certify to EPA that the VAs were conducted, and submit a copy of the VA to EPA. The DWSP worked with the MWRA to complete a VA for the water supply systems under its care. This VA was completed and submitted to US EPA for the entire water system on September 30, 2003.

As a result of this Vulnerability Assessment, the Division implemented short-term and long-term changes to its land management practices, as follows:

Short-term land management changes included:

- Closing public access to the Winsor Dam and other critical assets.
- Placing Jersey barriers across roadways with temporary fencing around potentially vulnerable areas.
- Blocking utility right-of-way access routes to unauthorized motor vehicles.
- Staffing check points by MA National Guards and MA State Police at main entrance points and Gate 17, and requiring staff id and other forms of identification.
- Suspending forestry and research access temporarily, while procedures were established for improving security checks on permit holders.
- Temporarily suspending access to fishing areas and other recreational use areas while the potential threat associated with these areas was evaluated.

Long-term land management changes included:

- Closing vehicle access to the Winsor Dam and Goodnough Dike.
- Prohibiting general public access around CVA Intake and Shaft 12 buildings including new fencing, locks, and signage.
- Enhancing Watershed Ranger patrols throughout the watershed.
- Requiring background checks for all research permits.
- Improving gate management, including numbering, inventory, and physical modifications to gates.
- Establishing an access management system with permits.

DWSP will continue to develop and refine its approach toward domestic incident management to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies.

5.2 Management of Forested Lands

5.2.1 History of Quabbin Watershed Forestry 1930 – 1960

5.2.1.1 Land Taking and Development for Water Supply

Forest Management Highlights:

1. Early forest management (1930-1970) at Quabbin focused on planting of 6,760 acres, pruning, limited non-commercial thinning, and extensive commercial improvement thinning. This was followed first by clearing of plantations to improve water yield (1980s), and then by deer herd reduction and small group selection silviculture to produce diverse forest structure (1990s to present).
2. From the approximately 47,000 acres considered to be actively managed at Quabbin, just over 1,000 acres has been treated annually since 1960. In recent years, about 400 acres of the treated area has been regenerated annually to form new age classes.
3. Forest management guidelines include cutting no more than 25% of the stocking of any given subwatershed in any given 10 year period and strict adherence to conservative Conservation Management Practices.
4. Harvesting is also limited by hydrologic zones based on proximity to water resources. Regeneration openings in Zone 1 will not exceed ½ acre; Zone 2 will not exceed 1 acre; and 90% of Zone 3 openings will not exceed 2 acres, while 10% will be larger.
5. Efforts to build diversity in size/age classes and in species composition are designed to build resistence and resilience in the face of disturbances ranging from wind and heavy snow/ice to diseases, insects, and climate change.
6. Management plan review, annual internal review of proposed harvesting and roadwork, and post-harvesting summary reports and public meetings provide wide-ranging internal and public review of DWSP forest management practices.

With signing of Chapter 321 of the Acts of 1927, the Quabbin Reservoir project had official approval to begin work. The bulk of the land purchasing in the Quabbin Reservation came with the "General Taking" of March 28, 1938. The "General Taking" is defined by the "fire line", a 40 foot clearcut swath along the DWSP boundary. Besides land taking, the agency was busy constructing dams, dikes, aqueducts, roads, highways, buildings, a power station, and Quabbin tower, and clearing the 24,000 acre reservoir and planting trees on 10,000 acres of open land. Most of this work was done in a period of 10 years. During this time, two major floods and a catastrophic hurricane occurred.

The clearing of 24,000 acres of all trees, and the subsequent flooding, impacted the Swift River Valley by eliminating most of the pine types, both white and pitch, all of the small ponds, miles of streams and significant wetlands. The clearing process created huge amounts of waste wood (slabs, branches etc.), which had to be removed; the only practical way was through burning. In the process of burning the debris, most of the present islands and hundreds of acres along the Reservoir shore and most of Quabbin Hill were extensively burned. These woodland fires stimulated the development of hardwood sprouts and seedlings throughout the burned areas. Tremendous amounts of deer food were produced by both the clearing and burning. Although the fires burned hot and killed small trees, they did not kill larger overstory trees. An exception was a later fire in 1957 which did kill the overstory. This fire was just north of Route 122 in New Salem and resulted in the death of 100 year old pines and hemlocks on 400 acres.

The construction of two large earth dams required huge amounts of soil. This resulted in the development of several open pit mines adjacent to the Reservoir and the stripping of 2-3 feet of top soil from most fields on agency lands in the town of Ware. Most stripped areas were planted to conifers. These plantations have shown the effects of soil loss, often including disease, stunted growth, and frequent wind-throw.

During World War II, the military established a presence at Quabbin with a firing range at the south end of Little Quabbin and several bombing and strafing ranges for aircraft. Most of this activity had little impact on

the land except for fires started by 100 lb. practice bombs. Many bombs ended up a considerable distance from the targets, and one of these ignited a fire that burned 2,000 acres of the northeast corner of Prescott Peninsula. It was a hot ground fire fueled with blow-down from the 1938 hurricane. The fire crossed several roads before topography and wetlands stopped its spread. The fire opened the forest, fostering the production of an understory of hardwood sprouts and seedlings.

In the first years after it acquired watershed lands, the MDC harvested forest products to provide for its own lumber needs. A private sawmill owner could bid on sawing a certain amount of lumber for the agency. Sawmills would be set up near the forest where the trees were to be cut. During the late 1940s and through the 1950s at least four cuttings were made to meet these needs. In addition, several private timber sales were conducted in the 1950s both inside and outside gated areas of the Quabbin. Prior to 1960, the total volume of timber removed by these cutting operations after MDC attained care and control of the properties was less then 5 million board feet (excluding hurricane salvage).

5.2.1.2 Establishment and Management of Plantations on Open Lands

A forestry program for the reforestation of open land and of areas growing brush was initiated in 1934 for the better protection of the watershed, with the goal of establishing a revenue-producing watershed forest. Coniferous trees were chosen for the following benefits:

- Prevention of the growth of deciduous trees so that leaves are kept from entering the water and undesirable color and taste produced by decomposing organic material is minimized.
- Reduction of the force of heavy rains through dispersal of rain drops into a fine spray by the coniferous foliage, thereby increasing the absorption of precipitation by the soil.
- Control of snowmelt in the spring due to the dense shade beneath the coniferous canopy as opposed to the rapid melting and evaporation that takes place in open areas and in deciduous forests.
- Conservation of soil moisture in deeper soils due to the shallow rooting of conifers.
- Fast growth of coniferous trees and the value of the quality timber they produce.
- Ability of conifers to grow well on a wide range of sites.

Red pine was specifically favored because it was resistant to blister rust and white pine weevil, was easily grown in the nursery, and survived transplanting well. During the period from 1935 to 1946 approximately 8,243,600 pine trees were planted on roughly 6,760 acres of open land. These areas consisted of:

- Arable land. This land grew agricultural crops for human consumption or forage for feeding domestic animals. When agriculture declined much of this land was used as pastureland. Most of the soils consist of fine sandy loams such as the Charlton series.
- Pasture land. This is land on which domestic animals had been pastured, but it was open land, not pastured woodland. The majority of these soils were moderately well-drained fine sandy loams such as the Scituate series.
- Sproutland. This land had dense shrubby vegetation or trees of seedling or sapling size. The land had recently (1 - 15 years) been withdrawn from agricultural use and was not cut over woodland.

Many of the 6,760 acres of original plantation failed, generally by succumbing to competition from native species. Plantations survived beyond the establishment stage on approximately 3,200 acres. Trees were

planted in straight rows, mostly five feet on center. This "five-by" spacing insured a rapid closing of the crowns in order to prevent the development of large branches on the lower portions of the trees, produce straighter stems, and eliminate much of the danger of insect damage.

With this spacing, crown closure occurred within 15-20 years. At this point, these stands were to receive some kind of silvicultural treatment such as a thinning. This did not happen due to lack of labor and available markets. As a result of overcrowding and competition for water and nutrients, growth rates in many stands became stagnated. The stands remained stagnated, except for a limited number that were commercially thinned in the late 1950s. During the 1960s, approximately 630 acres of plantations were pruned and 730 acres received some type of pre-commercial thinning. In most instances, these operations occurred simultaneously.

The decade of the 1970s saw a move from non-commercial to commercial silviculture, and thinnings occurred on about 800 acres of pine plantations. During this period the region experienced a drought and water quantity became a great concern. Ongoing studies on the Cadwell Creek experimental watershed and others showed that water yields could be increased by lowering the stocking of the forest and that greatest increases in yield occurred when the forest was completely removed from a watershed area. With water yields as the goal, approximately 400 acres of stagnated or diseased plantations were clear-cut and converted back into fields during the decade of the 1980s. This figure was considerably less than the 3,000 acres of plantation clearings that were outlined in the 1986 Forest Management Plan (the difference between the planned and actual removals was due to the need for careful supervision of private contractors and the limited number of available contractors).

During the 1980s, both intermediate and regeneration cuts continued, covering approximately 900 acres of plantations that decade. While many of these plantations were on hardwood sites, white pine regenerated well in most instances but hardwood regeneration was very limited due to deer browsing. Toward the end of the decade, MDC management philosophy changed with respect to pine plantations, when water conservation measures proved successful and the need to increase water yields was no longer a primary concern. Today, DWSP's principal concerns with its pine plantations are to maintain their ability to protect water quality, by increasing structural and species diversity and by replacing high risk stands (growing on wetter soils) through natural regeneration with native species more likely to persist on these sites.

5.2.2 Objectives and Accomplishments of Previous Quabbin Management Plans

5.2.2.1 Hunt's 1961 Assessment

The first "management plan" for the Quabbin forest was actually a Master's thesis written by MDC Forester Fred M. Hunt in 1961 and titled "Forest Resources on the Metropolitan District Commission Lands Surrounding Quabbin Reservoir." The management objectives outlined in this thesis were:

- Provide, through Continuous Forest Inventory (CFI), detailed information on the condition of the forest so that the forest manager could carry out sound management practices designed to improve the productivity of the watershed for both water and timber values.

- Determine through a study of the literature on the subject, the types of vegetative cover that would best suit the needs of this particular watershed.

- Develop, for each of the major timber types on the area, management procedures that would produce the types of cover determined above.

The recommendations necessary to meet these objectives were put forth in this document. The inventory, present condition of the forest, characteristics of good watershed cover and recommendations for watershed management were discussed in detail. Ideal forest conditions for the watershed were described as forest

composed of native species that were long-lived and suited to the site conditions. White pine, red oak, hemlock and white ash best fit these criteria. The forest would be of moderate stocking, have good growth and quality and include equal areas in each age class. This forest would promote a forest floor that allowed precipitation to rapidly infiltrate the soil and would enhance both aesthetic and wildlife values.

The recommendations were to conduct commercial silvicultural operations on 10,560 acres and remove approximately 35 million board feet of timber. Much of this work would be salvaging trees that had been partially damaged by the 1938 hurricane or trees which were of poor health, vigor and quality. Several thousand acres of non-commercial silviculture was also recommended, primarily in dense pine plantations and hardwood stands that had regenerated from the 1938 hurricane. These cutting practices were designed to improve stand health and where possible to allow regeneration to develop. Deer browsing was considered to be inhibiting forest regeneration on much of the reservation.

The recommendations of the plan were closely followed and a total of 32.5 million board feet was harvested on approximately 9,000 acres of watershed. Although a few hundred acres of non-commercial silviculture was completed with MDC personnel, this work stopped in 1964 when the workforce was assigned to maintenance of the Quabbin Park area.

During this decade a significant drought occurred and the Quabbin Reservoir dropped 34 feet below full elevation, the lowest level since its construction. The role of forest management in defending against such dramatic drops became an important topic of discussion.

5.2.2.2 Spencer/Walker 1972 Quabbin Watershed Management Plan

The first official MDC management plan was prepared by Bruce Spencer and Charles Walker in 1972 and titled "Watershed Management Plan for Metropolitan District Commission Lands Surrounding Quabbin Reservoir." The objectives of this plan were:

- Create and maintain an additional water yield of 10% annually from the Quabbin Reservation.
- Improve the health and quality of the Quabbin forest.
- Maintain healthy populations of native wildlife.
- Maintain, improve and protect an aesthetically pleasing landscape.

This plan followed and expanded upon most of the recommendations of Hunt's thesis. It also urged hiring more personnel to better care for the watershed. The condition of the forest was determined from inventory data collected from the remeasurement of several hundred permanent Continuous Forest Inventory plots (CFI). The implementation of silvicultural activities was detailed, especially commercial logging activities. Logging systems and methods to eliminate significant impacts to water, forest, wildlife and aesthetics were outlined. The watershed was zoned for forest management, administrative uses, and natural areas.

Deer still prevented regeneration on large areas of the watershed but the recommendation was to delay corrective action for 15-20 years, acknowledging that the absence of regeneration might enhance water yields. However, this plan stressed that a solution to heavy deer browsing be found at the end of that period, to compensate for the maturation and gradual break-up of the overstory.

Beaver, introduced in 1952, were spread throughout the entire watershed by 1972 and responsible for creating approximately 1,200 acres of ponds and marsh. Although the damage to forests and road culverts from beaver was noted, the benefits to other wildlife were also mentioned. Beaver management was recommended only where the road system was threatened.

The plan recommended silvicultural operations on 12,000 acres of natural stands, thinning 3,000 acres of pine plantations and clearing 500 acres of stagnated and diseased pine plantations. Thirty one million board feet of timber was expected to come from these operations.

During the plan period, silviculture was conducted on 9,500 acres, yielding 20.5 million board feet of timber and 30 thousand cords of firewood. Approximately 75 acres of pine plantations were salvaged and cleared due to storm damage or disease. A new demand for firewood allowed thinning of overstocked stands that had been scheduled for work by MDC crews in the first plan. Only a small amount of thinning was done in pine plantations because there was little commercial demand for the wood and no budget to pay for non-commercial thinning. The difference between planned and completed work during this decade highlights the importance of market conditions in accomplishing necessary work.

5.2.2.3 Spencer/Lyons 1986 Quabbin Watershed Forest and Wildlife Management Plan

The second MDC management plan was prepared by Bruce Spencer and Paul Lyons in the early 1980s. The plan was titled "A Ten Year Forest and Wildlife Management Plan for the Quabbin Watershed." The objectives of this plan were:

- Identify and protect critical, sensitive, rare or otherwise valuable habitat.
- Thin forest stands to reduce stocking levels to 20-40% (i.e., savannah forest) or 60-70% (i.e., "thinned forest").
- Convert several thousand acres of conifer plantations to open grass cover.
- Plant important wildlife food/cover species.
- Diversify wildlife habitat conditions on the Reservation using a variety of other management practices.

These objectives supported the primary goal of increasing water yields while maintaining water quality and vigorous forest and wildlife communities. The plan strongly supported the addition of more MDC personnel to better care for the watershed. The plan expanded the discussion on all aspects of management such as the landscape design aspects of watershed management, methods of determining the recommended harvest, and a discussion of the dynamics of water yields.

The goal of striving for multiple age classes of native species suited to site conditions was reiterated, although browsing and associated herbaceous competition (ferns, barberry, and assorted others) had prevented and would continue to prevent the development of new age classes on 2/3 of the hardwood forest. The need for regeneration to replace the forest following a disturbance was again discussed.

Specific recommendations were made to work on 23,000 acres (20,000 acres of silvicultural practices and 3,000 acres of pine plantation conversions to fields) and harvest 33 million board feet, 150,000 cords and 400,000 tons of chips (red and white pine plantations).

The actual acreage worked was 11,450 acres from which 13.8 million board feet, 39,000 cords of firewood and 141,600 tons of whole tree chips were harvested. Of the 3,000 acres of pine plantations to be converted to fields, 400 acres were actually completed. Although the pines could have been marketed and MDC would have realized income from this project, contractors with the proper equipment were not available.

The firewood market collapsed in the last half of the decade and therefore much of the hardwood thinning was not completed. The creation of savannah forest via harvesting, which would then be maintained through

deer browsing, was discontinued. It was felt that water-rich areas produced similar yields regardless of whether the vegetation was mostly ferns or trees.

Additional staff and equipment were added to better care for the watershed and to maintain the roads and forest. Some roads had become an erosion problem due to insufficient staff and equipment. With a combination of new equipment and personnel plus monies from timber sales to supply gravel, trucking, culverts, gates and other equipment and supplies, much of the forest road mileage was restored to good condition. Equipment to operate within pine plantations while avoiding damage to walls, foundations, and advance regeneration was purchased for operation by MDC personnel. The purchase and installation of additional gates to control access was also accomplished. Starting in the last half of this management period, an action plan to solve the deer problem was implemented.

Table 38 presents the number of acres treated since the 1960s. A decline in acres treated in the 1980s was due to the decreasing ability of the forest to regenerate, changes in forest product markets, and the assignment of forestry staff to other projects including forest inventory, management plan preparation, boundary marking, and land acquisition.

Table 38: Acres of Silvicultural Treatment by Fiscal Year, 1960-1995

Year(s)	Acres treated	Year(s)	Acres treated
1960s	9,000	1987	645
1970s	9,500	1988	1,232
1980	2,202	1989	940
1981	1,037	1990	404
1982	1,831	1991	722
1983	1,598	1992	507
1984	1,369	1993	704
1985	1,512	1994	945
1986	1,169	1995	786

5.2.2.4 MDC Quabbin Land Management Plan 1995-2004

The third Quabbin Land Management Plan was prepared shortly after the initiation of deer impact control through public hunting (in 1991) and just before the management of these lands became the first public land management in North America to receive "green" certification from the international Forest Stewardship Council (in 1997).

The 1995-2004 plan identified both short-term (10 year) and long-term (60 year) objectives. The primary objective in the short term was to manage for the recovery of tree regeneration, a component of the forest structure that had been severely restricted for fifty years due to uncontrolled expansion of deer browsing. This objective was to be met through a combination of reductions in the size of the deer population and specific forest management practices, such as preparatory cuttings and enrichment plantings. The long-term objectives were to bring about the development of a multi-aged, species-diverse forest that was determined to be the most stable cover for this drinking water supply, especially in the face of potential large-scale disturbances by wind, ice damage, or insects and disease, among others. Long-range objectives also included a proposed effort to identify priority areas for treatment based on a "sub-basin" analysis, to determine which areas had the greatest influence on water quality. The plan also called for the creation of a Scientific and Technical Advisory Committee to assist Division staff in setting priorities for management.

The first objective of the plan, to reduce deer impacts, was addressed very successfully during the 1995-2004 period, and this success continues today. Deer populations across the watershed were reduced to

levels that allow tree regeneration to become established and begin to grow into new age classes. The specific silvicultural objective was to regenerate one-third of approximately 1,500 to 2,000 acres treated per year, or about 500 to 600 acres regenerated annually. **Table 39** details the silviculture that was actually completed during the decade of this plan, which averaged 388 acres regenerated annually from a total of approximately 1,000 acres treated.

Table 39: Harvesting Summary for FY1995 through FY2005

Fiscal Year	Total Acres Harvested	Total Acres Regenerated[1]	Board Feet	Cords	Tons	Revenue
1996	659	85	2,645,494	1,994	3,458	$306,048
1997	1,274	682	7,447,357	3,495	9,215	$727,993
1998	1,253	385	4,894,431	4,908	1,569	$677,017
1999	1,332	382	5,327,581	4,974	7,410	$567,504
2000	1,110	419	5,042,700	3,884	6,221	$1,028,977
2001	745	371	4,532,600	2,703	8,059	$524,075
2002	808	380	4,196,880	2,646	7,665	$571,601
2003	1,003	397	5,575,799	4,150	8,645	$704,882
2004	890	337	2,873,334	4,095	5,170	$381,540
2005	1,205	439	5,146,694	5,598	6,864	$757,708
TOTAL	**10,279**	**3,877**	**47,682,870**	**38,447**	**64,276**	**$6,247,345**
Average	*1,028*	*388*	*4,768,287*	*3,845*	*6,428*	*$ 624,734*

[1] Note that the regeneration objective was to regenerate approximately one third of each harvesting sale area, unless the treatment was exclusively intermediate thinnings. The difference between harvested area and area regenerated is intentional and does not imply regeneration failure.

5.2.2.5 Regeneration Changes during the Previous Management Period

Regeneration has been systematically and intensively monitored on the Quabbin Reservoir watershed since 1989 and throughout the previous management period. A summary of results from this monitoring is included as an Appendix to this plan, entitled "2004 Quabbin Regeneration Summary Report." Shorter updates are produced by DWSP annually, to serve as the backdrop for annual deer impact control management programs (see summary of deer program results in Section 5.4.4.4.). The deer impact control program that is in place has been very successful in reaching DWSP goals for the re-establishment of regeneration potential and diverse plant succession throughout even the most heavily impacted areas of the watershed. **Table 40** provides a comparison between the conditions encountered in the regeneration surveys conducted in the late 1980s and early 1990s and the conditions recorded in the most recent watershed-wide intensive regeneration survey.

White pine and black birch regeneration beneath thinned red pine plantation on Prescott Peninsula

Table 40: Regeneration Comparison 1989, 1994, 2004

Area / Block	Year	Stems per acre 1' to 4.5' tall	Stems per acre >4.5' tall	TOTAL
Off Reservation	1989	1,960	1,140	3,100
	1994	2,750	1,840	4,590
	2004	2,071	1,404	3,475
On Reservation	1989	770	130	910
	1994	2,955	417	3,372
	2004	3,187	1,344	4,531
Hardwick	1994	1,840	581	2,421
	2004	2,634	1,333	3,967
New Salem	1994	3,846	212	4,058
	2004	3,399	950	4,349
Pelham	1994	930	71	1,001
	2004	2,102	901	3,001
Petersham	1994	4,369	1,054	5,423
	2004	4,438	2,008	6,446
Prescott	1994	3,789	167	3,956
	2004	3,267	1,331	4,598

5.2.3 DCR/DWSP Quabbin Forest Management Objectives 2007-2017

DWSP has concluded that the forest conditions that best meet the combined objectives of the agency – to deliver predictable quantities of high-quality drinking water at a reasonable cost while protecting the fullest possible suite of associated natural resources – include vigorous trees of broad, site-suited species composition and age classes well-distributed across the watershed and capable of rapid regeneration and active growth following a wide range of both natural and deliberate disturbances. This conclusion was reached through critical review of past and current research literature, consultation with an extensive array of academic and field professionals in natural resources management and related disciplines, and more than four decades of direct experience with watershed forest management. The conclusions of the agency have been open to critical and timely revision by the public that is served by these objectives. Throughout this management period DCR will continue to solicit public input as adaptive revisions are proposed during annual progress reviews, based on additional experiences and changing objectives.

Note that the objectives listed in the following sections refer to those areas of the DWSP holdings around Quabbin Reservoir that are actively managed, an area that includes approximately 46,000acres. These objectives specifically exclude those areas that are identified as reserved from management, as described in Section 5.5.4, Areas with Special Management Restrictions, and totaling approximately 12,000 acres.

5.2.3.1 Primary Objectives

The primary objective of forest management of the Quabbin forest is to create and maintain a complex forest structure, which forms a protective forest cover and a biological filter on the watershed land. This watershed protection forest is designed to be vigorous, diverse in species and age, actively accumulating biomass, conserving ecological and economic values, actively regenerating, and most importantly maintaining a predictable flow of high quality water from the land.

From 1960 to 1990, the primary objective of forest management at Quabbin was to maintain vigorous forest growth through silvicultural thinning and stand improvement harvests. Regeneration of all species was not possible throughout much of the Quabbin until the successful deer impact management program that began in 1991. Regeneration potential is essential to restore the forest cover as quickly as possible following any disturbance and to enable the deliberate creation of diverse age classes. Based on results from past surveys, the primary regeneration objective of this plan is for areas that have been deliberately regenerated to contain an average of at least 2,000 trees per acre greater than 4.5 feet in height, of a diverse mix of species appropriate to the site, within 3-7 years of the disturbance This management plan will be the first of five plans to work with an actively regenerating forest throughout the Quabbin reservation, enabling the gradual fulfillment of our watershed protection forest structure objectives.

The present Quabbin forest overstory originated as stands that regenerated following farm abandonment from 1850-1900 and subsequent cutting, or by stands that regenerated following the hurricane of 1938 and by the deliberate planting of trees on agricultural fields at approximately the same time, so that the range of overstory ages is generally between 65 and 160 years of age. During the past decade, the Division has successfully regenerated approximately 3,900 acres, or 8.5% of the actively managed forest (approaching the objectives of the 1995-2004 Quabbin Land Management Plan to regenerate approximately 1/3 of the managed forest every 30 years).

Converting the present day even-aged forest stands into a multi-aged forest is a long process (Kelty, et al, 2003) that will not be fully implemented for many decades, and will most certainly be disrupted by frequent small and infrequent large disturbances. The guiding objective for silviculture during the decade of this plan will be to regenerate approximately 1% of the managed forest annually, so that by the end of the decade, an additional 10% of the managed forest will have been converted to a new age class. Large, unmanaged stands that will include individuals and groups of trees living to biological maturities ranging from 100 to 400 or more years of age, will, barring major disturbances, continue to be a component of the

watershed protection forest surrounding Quabbin Reservoir..

The managed forest that was regenerated in the past decade was distributed throughout the forest types and origins, with some emphasis on replacing failing pine plantations established in the late 1930s (some of these plantings were established on sites not suited to their long-term growth and development). Managing the mix of stands from the 1930s and those from an earlier time has required the application of varied silvicultural systems. Generally, stands dominated by long-lived trees, well suited to the site, have been treated with uneven-aged silvicultural methods ranging from single tree to small group selection harvests (up to one acre in size). In stands dominated by trees not suited to the site, various methods within the even-aged silvicultural system have been used to more rapidly regenerate these stands to trees better suited to the site conditions. The vast majority of the Quabbin forest is currently occupied by species growing on suitable sites.

Over the next decade, the Division intends to refine its silvicultural techniques while continuing to implement the primary objectives stated in the previous plan. Silvicultural practices will work to maintain or enhance species diversity. Age structure will become more diverse. Approximately 1% of the managed forest will be regenerated annually to create a new age class. The majority of the harvesting will focus on regeneration openings ranging from single-tree to small group selections (less than one acre in size) and patch cuts up to 2 acres in size. On a limited basis, larger openings will be implemented to more rapidly regenerate some areas and to meet green certification recommendations to enhance landscape-level horizontal forest diversity. Full details of the proposed zoning and silvicultural approach are included in Section 5.2.3.3.

The Division will consider the current condition of individual management units (such as the presence of significant insects or diseases), and inventory the condition of the access network (roads, staging areas) in order to plan for upgrades as necessary and limits on the size and type of equipment that can operate the area. Areas with special management restrictions, such as rare species habitats or cultural features requiring heightened protection, will be identified, and then the specific silvicultural prescription will be proposed through the annual Lot Review process (see Section 5.2.7).

5.2.3.2 Subwatershed Administration of Forest Management

While the focus of DWSP's mission is the overall condition of the watershed and the quality of the water in the reservoir, those conditions reflect the collective conditions of a group of smaller drainages, or subwatersheds that comprise the whole. The planning process for land management, public recreation, and other watershed activities is therefore most logically done on a subwatershed basis.

Historically, records on forest management activities on Quabbin Reservation have been based on a "compartment" system. 94 compartments were established on the reservation, usually bounded by roads, streams, the reservoir shoreline, or other obvious natural features. As new lots were sold and operated, their locations and other pertinent information were added to maps and tables for each compartment, first manually and later by computer.

While this system has proven useful for record-keeping purposes, it does not allow for the efficient monitoring of land management activities on a drainage area basis. However, with the advent of Geographic Information Systems (GIS), Global Positioning Systems (GPS), and high-quality digital orthophotos of the watershed, it is now possible to efficiently keep track of our management work by hydrologic units or subwatersheds.

5.2.3.2.1 Quabbin Subwatersheds

A subwatershed is defined in most cases as the land area that drains to a perennial tributary of the reservoir. Drainage areas were delineated using the MassGIS watershed delineation tool, starting from

the point where the tributary met the reservoir. In most cases, these were 2nd or 3rd order streams. Where those tributaries represent higher-order streams or rivers however, they were further subdivided. This process resulted in the identification of 56 subwatersheds on Quabbin (**Figure 14**). There are areas within the watershed, and in particular along the shorelines, that drain directly to the reservoir via subsurface flow rather than via a distinct tributary. These areas are not distinct subwatersheds flowing through a unique collection point at the reservoir's edge, but are critical direct drainage areas that lie immediately adjacent to the reservoir.

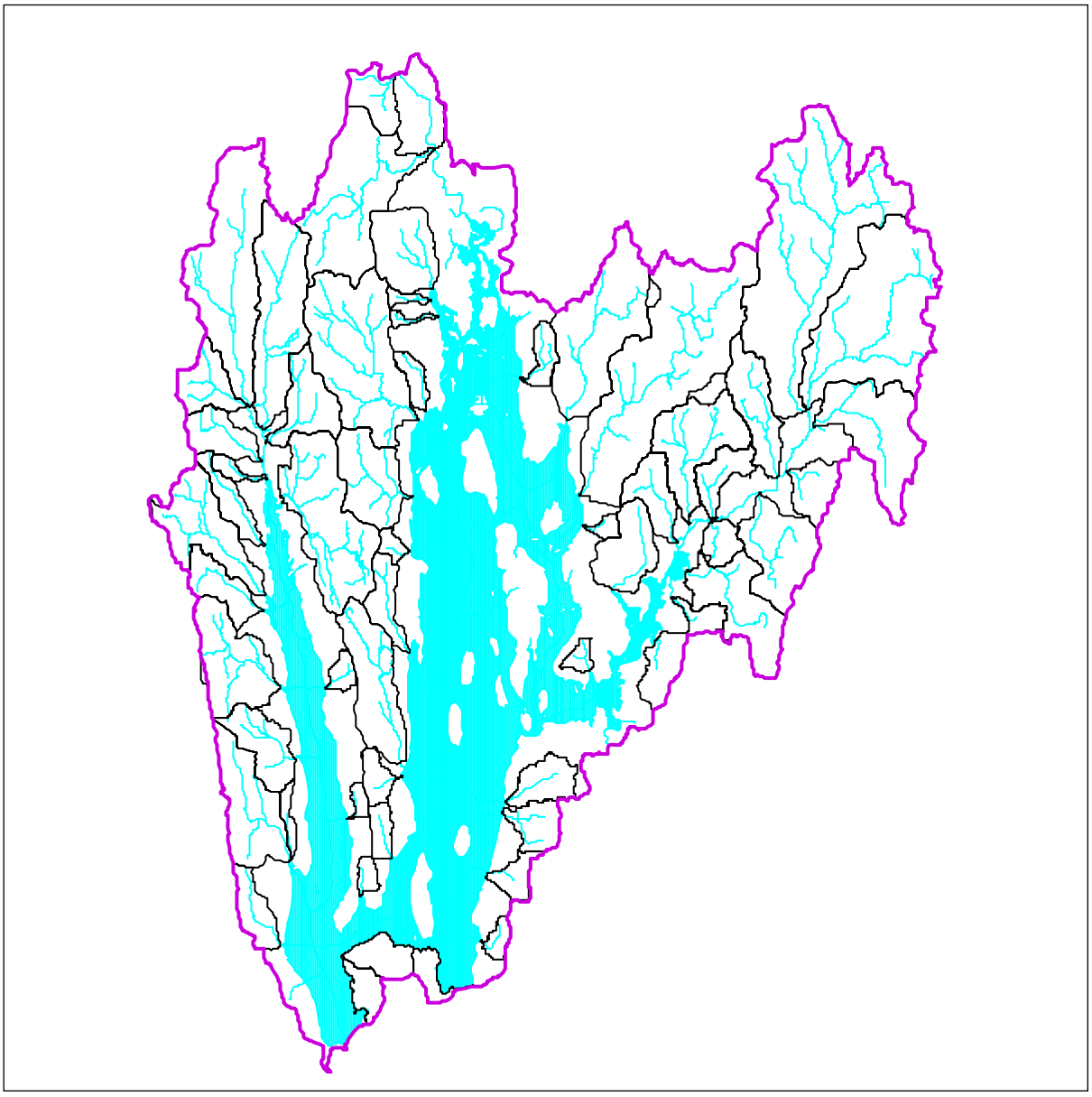


Figure 14: Subwatersheds and direct drainage areas within the Quabbin Reservoir watershed

5.2.3.2.2 Implementing Subwatershed-Based Planning

The general theory behind the use of subwatershed-based planning is to control the proportion of a drainage area that is "disturbed" by management activities (e.g., logging or roadwork) during the management period in order to reduce the chances of water quality impacts. This approach is partly based on research on experimental watersheds throughout the eastern US that indicate that until approximately 25-30% of the watershed forest overstory stocking is harvested (assuming nearly 100% forest cover type),

there is a no detectable increase in water yield (Hornbeck and Kochenderfer, 2004; Hornbeck et al., 1993). As increases in transport of sediments and nutrients to tributaries and the reservoir are directly related to increases in water yield, it follows that the 25-30% threshold also applies to water quality changes (so long as Conservation Management Practices are in place, the greatest concern is with the movement of nutrients rather than sediments; see Section 5.2.5). The same research also demonstrated that water yield generally returns to pre-harvest conditions as the harvested area regenerates – usually within 3-10 years.

Once drainage areas have been delineated and the locations of harvest operations have been digitized, the GIS provides straightforward techniques to estimate the percentage of a subwatershed forest that has been harvested in any given time period. That information will be available to DWSP Foresters before they propose their logging operations for the coming year. Where the forest stocking across any given subwatershed has been reduced during the previous decade by an amount approaching 25-30% of full stocking, further harvesting in those drainages will be postponed. This percentage may be estimated based on the area of regeneration openings versus the total area of the subwatershed, or through stocking estimations.

While the 25-30% figure provides a guideline for meeting water quality standards, other factors, such as soil types, topography, proximity of the management work to water courses, and the concentration and distribution of the harvesting can affect the decision about acceptable levels of harvesting. Another consideration in subwatershed-based planning is the proximity of a subwatershed to the water intake structures. Those subwatersheds that are far removed from the intakes could be considered less sensitive to management effects than those in close proximity. In each individual instance, subwatershed–based recommendations will be tempered by best professional judgment.

To facilitate the use of subwatershed information in land management planning, maps of each subwatershed will be produced, showing boundaries, topography, soils, roads, and locations of logging operations conducted during the past 10 years. Foresters will then consult these subwatershed maps prior to planning their coming year's work.

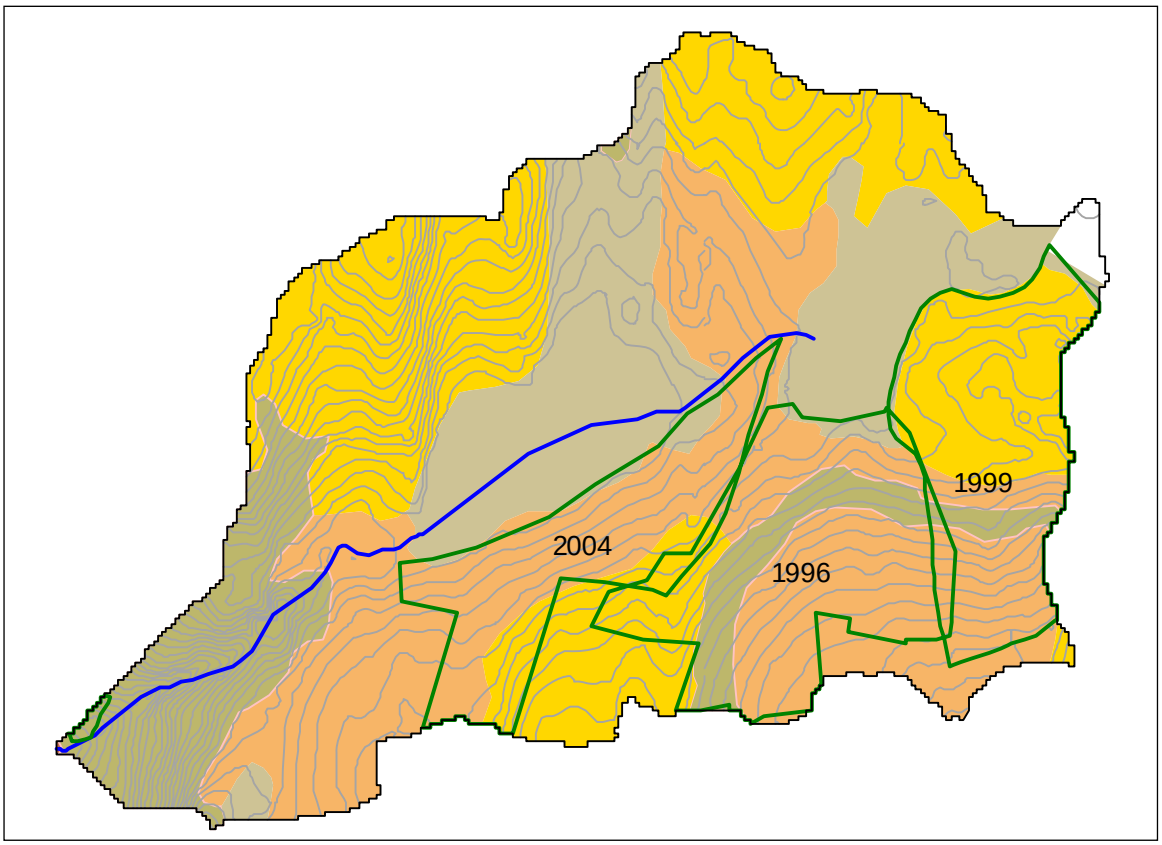
An example of an individual subwatershed map is shown in **Figure 15**. This subwatershed is approximately 638 acres in size, with topography ranging from 531 to 954 feet. The mouth of the drainage is within 1.3 miles of the Shaft 12 intake, and approximately 6.6 miles from the CVA intake. Soil composite types in the subwatershed include: Well-drained thin soils – approximately 33% of subwatershed; Well-drained thick soils – 12%; Moderately-well drained soils – 34%; Poor to very poorly drained soils – 21%. During the past 10 years, 3 logging operations occurred in the subwatershed, covering a total of approximately 210 acres (33% of the subwatershed). However, this work harvested the overstory trees on only 70 acres (11%) of the actual area, and mostly occurred on the moderately or well-drained soils in the subwatershed, so this area remains well below the 25-30% threshold.

5.2.3.2.3 Coordination with OWM Environmental Quality staff

The Environmental Quality (EQ) staff at Quabbin have developed a multi-tiered system for subdividing the watershed for the purpose of organizing the tracking and analysis of management or development activities on private as well as public lands and for monitoring the effects of these activities on water quality. The Quabbin Reservoir watershed is divided by EQ into Districts, Subdistricts, and Stream Compartments. The Stream Compartments correspond most directly with the subwatersheds designated above for the purposes of land management, with some important differences. For example, the shoreline direct drainage areas are merged into Stream Compartments for EQ analysis. For land management purposes and the determination of the 25-30% threshold described above, the only portions of shorelines that can be used in this analysis are those with distinct watersheds. The remainder of the shorelines is primarily drained by subsurface direct flow to the reservoir. Despite this difference in the systems, the EQ and Natural Resources (NR)/Forestry staffs will accumulate information at the EQ Subdistrict level

on at least an annual basis in order to better coordinate responses to mutual concerns. For example, EQ will inform NR/Forestry on the status of private land activities within each subdistrict, and NR/Forestry will provide EQ with a summary, by subdistrict, of past and proposed regeneration harvesting.

Figure 15: Example of a Subwatershed Planning Map Including Topography, Soils, and Previous Harvests



5.2.3.3 Establishment of Forest Management Zones

5.2.3.3.1 Guidance from existing zoning strategies

Once subwatersheds are established, DWSP next establishes three zones within the areas that are to be actively managed. These zones were developed following consideration of other regulatory zoning that affects watershed management practices. DEP, the primary regulator for MA surface water supplies, established three zones to delineate those areas included in 310 CMR 22.00, the Massachusetts Drinking Water Regulations, as Surface Water Supply Protection Zones:

- ***ZONE A:*** represents a) the land area between the surface water source and the upper boundary of the bank; b) the land area within a 400 foot lateral distance from the upper boundary of the bank of a Class A surface water source, as defined in 314 CMR 4.05(3)(a); and c) the land area within a 200 foot lateral distance from the upper boundary of the bank of a tributary or associated surface water body.

- ***ZONE B:*** represents the land area within one-half mile of the upper boundary of the bank of a Class A surface water source, as defined in 314 CMR 4.05(3)(a), or edge of watershed, whichever is less. Zone B always includes the land area within a 400 ft lateral distance from the upper boundary of the bank of the Class A surface water source.

- ***ZONE C:*** represents the land area not designated as Zone A or B within the watershed of a Class A surface water source, as defined in 314 CMR 4.05(3)(a).

In addition, the Watershed Protection Act established regulatory zones restricting land use and activities within critical areas of the Quabbin Reservoir, Wachusett Reservoir and Ware River watersheds. These zones include two distinct areas, the *Primary Protection Zone*, which is the area 400 feet from the edge of the reservoirs and 200 feet from tributaries and surface waters, in which alterations are prohibited, and the *Secondary Protection Zone,* which is the area between 200 and 400 feet from the banks of tributaries and surface waters, and within which storage, disposal, or use of hazardous materials, the alteration of bordering vegetated wetlands, and dense development are prohibited.

Finally, in 1999, the Division identified a "Pathogen Control Zone" designed to limit the risk of pathogen infection of the water supply at the intakes. At Quabbin, this zone is focused on protecting the Chicopee Valley Aqueduct, and includes the stream and hillside drainages in the Pelham Block and within Quabbin Park that most directly affect the CVA (see **Figure 22,** Section 5.4.4.1.1**).**

5.2.3.3.2 DWSP Forest Management Zones

For the purpose of guiding and limiting forest management activities within Quabbin watershed, DWSP has incorporated principles from the DEP zoning for surface water protection, the Watershed Protection Act, and the Division's Pathogen Control Zones and has developed the following forest management zones (see **Figure 16**):

5.2.3.3.2.1 DWSP Forest Management Zone 1

Zone 1 includes the buffer strips along public roads, the variable width filter strip along streams and water bodies, the DWSP filter strips around all vernal pools, and all other land that is within 200 feet of the bank of tributaries to the Quabbin Reservoir or within 400 feet of the bank of the reservoir itself.

Buffer strips are required by Chapter 132 along publicly maintained ways, but not including forest management roads in public forests, parks or reservations. These buffer strips are 50 feet from the edge of the road unless the road is a designated scenic road, in which case the buffer strip extends 100 feet from the highway. Within these buffer strips, cutting is limited to not more than 50% of the basal area and cuttings in these strips must be separated by at least five years time.

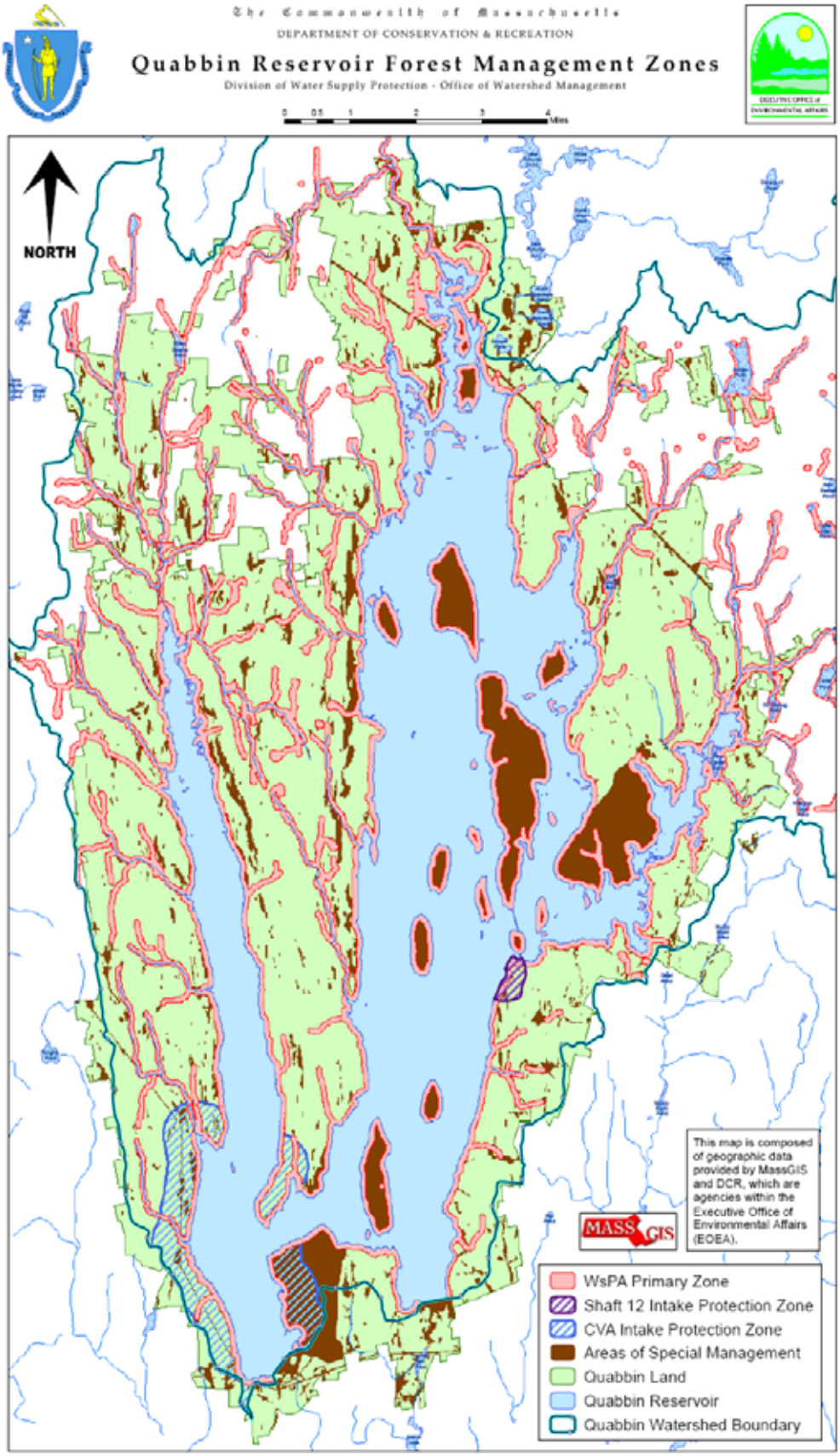
Filter strips are required along all water bodies and certified vernal pools (note that the Division treats all vernal pools as certified, whether or not they have been officially certified). Filter strips are a minimum of 50 feet in all cases, and are of variable width depending on slope along Outstanding Resource Waters (ORW) and their tributaries. Since Quabbin Reservoir is an ORW, all tributaries under DWSP control that also lead into the Reservoir are treated with variable width filter strips.

Vernal pools within DWSP holdings are treated as certified, and therefore subject to the 50 foot minimum filter strip requirement, within which not more than 50% of the basal area may be cut within any five year period. Further details for harvesting around vernal pools are included in **Figure 18 (page 180)**.

In some cases, variable width filter strips may exceed the limits of Zone 1 (for example, where a steep bank mandates a variable width filter strip that is greater than 200 feet wide). Where this is the case, the filter strip boundary determines limitations on harvesting.

In total, Zone 1 covers at least 13,857 acres (this is the acreage in DEP Zone A), or about 24% of the DWSP properties surrounding Quabbin. A smaller area of 7,933 acres is in Zone A and within the manageable portions of the property (i.e., not including islands, steep slopes, Pottapaug Natural Area, etc.; see **Table 41**). Zone 1 represents about 17% of the manageable area.

Figure 16: Quabbin Forest Management Zones



5.2.3.3.2.2 DWSP Forest Management Zone 2

Zone 2, also referred to here as the Intake Protection Zone, is a modified version of the Pathogen Control Zone and the DEP Zone B. For the CVA, this zone includes the area within ½ mile of the portions of the reservoir identified in the Pathogen Control Zone. For the Shaft 12 intake, this Intake Protection Zone is the land that is within a ½ mile radius of the intake, but also no further east than the watershed divide that sheds water either to the west or the east of the baffle dam. The CVA Intake Protection Zone includes 2,435 acres; the Shaft 12 Intake Protection Zone includes 128 acres.

Zone 2, CVA Intake Protection Zone

5.2.3.3.2.3 DWSP Forest Management Zone 3

Zone 3 is the land that is outside Zones 1 and 2 and is hydrologically the most remote zone from the reservoir. This zone covers approximately 36,179 acres or about 62.3% of the DWSP properties surrounding Quabbin. Zone 3 covers about 77.5% of the manageable area.

5.2.3.4 Harvesting Limits Within and Among Zones

As described in section 5.2.3.2, the Division will limit harvesting on a subwatershed basis to not more than 25% of the subwatershed forest cover in any given 10 year period. To reflect both the regulatory limitations and the hydrologic sensitivity of the three zones described in section 5.2.3.3, DWSP will further limit its harvesting activities within each zone.

- In Zone 1, harvesting and wetlands protection regulations require certain limitations on silvicultural practices. In order to address these regulations and the heightened hydrologic sensitivity of these areas, cutting within Zone 1 will be limited to:
  - Single-tree selection or small group or patch selection up to 0.5 acres in size, unless Chapter 132 is more limiting.
  - Within filter and buffer strips, cutting is limited to 50% of the basal area at one time, with a five-year waiting period between harvests, and the residual forest trees must be well-distributed and in good, vigorous health following the harvest.
  - Cutting around vernal pools is described in detail in **Figure 18 (page 180)**.

- In areas of Zone 2, the Intake Protection Zone, that overlap Zone 1, the restrictions on Zone 1 will prevail. In the remainder of Zone 2, harvesting will be limited to single-tree or small group or patch selection, with group/patch size limited to a maximum of one acre.

- Within Zone 3, considered to be hydrologically the most remote zone, harvesting will be in single tree, small group, and patch cutting, with the majority in groups and patches under 2 acres in size, but also including a limited number of larger openings as described below.

With a target of regenerating approximately 400 acres per year, regeneration harvesting will be controlled among all zones. Each year, at least 90% (360+ acres) of the regeneration cutting will be in single tree or small group selection harvests not to exceed 2 acres, and completed within Zone 1 (single tree and small group selection up to 0.5 acre), Zone 2 (single tree and small groups not larger than 1 acre), and Zone 3 (single tree and small groups not larger than 2 acres).

On a limited basis, DWSP will harvest patches greater than 2 acres in size. During the original Forest Stewardship Council certification of Quabbin land management practices by auditors from SmartWood in

1997, the audit report recommended that the Division should include "new management strategies that will maintain and promote biodiversity at the landscape level" (SmartWood, 1997). This recommendation derives from SmartWood observations under Criteria 3.11 for certification, regarding silvicultural prescriptions. SmartWood expressed the concern that, "In many areas on the Quabbin Watershed, the exact same silvicultural prescription is being marked and implemented. The ecological concern is that this will, over time, create a homogenous forest and greatly reduce horizontal diversity." The auditing team recommended that canopy gap sizes should be adjusted to address this concern. While the Division remains committed to the concept of diversifying the forest on the stand level in order to build resistance and resilience, there are hydrologically more remote areas on which achieving landscape-level horizontal diversity through the creation of larger openings is desirable.

In addition, there are occasionally situations in which full removal of the overstory of a stand of trees, even within an overall silvicultural strategy of developing stand level diversity, makes more sense than partial removal. Examples include densely planted artificial stands that were located on wetter sites and were never thinned. Due to the very weak form of the individual trees in these stands, partial cutting frequently leads to wind throw of the remaining stand. There may also be situations in which disease has entered a stand and is threatening to spread farther. In these situations it is sometimes desirable to cut out the entire diseased portion of the stand to prevent further spread and/or to more rapidly regenerate the stand to a more resistant mix of species. Finally, there are areas within the watershed forest that are hydrologically remote from the reservoir and on which it would be desirable to open a large area in order to produce early successional habitat for the benefit of certain wildlife species. Larger openings focus the harvesting on a smaller percentage of the management unit and can thereby reduce the percent of the area that is traveled by the harvesting equipment. Furthermore, these larger areas of regeneration do not require additional tending to release established regeneration. As the actual transport of the harvested trees presents a greater challenge to protecting water quality than the cutting of those trees, the reduced transport traffic may be an important benefit of larger openings in some areas.

In response to the recommendations for maintaining structural diversity at the landscape level, and to allow some flexibility for full overstory removals, each year up to 10% (40 acres) of the regeneration cutting will be in patches greater than 2 acres in size. These larger openings will be completed within Zone 3 only.

In addition to being at least 400 feet from the bank of the reservoir and at least 200 feet from the bank of any tributary to the reservoir, openings greater than 5 acres will *not* take place within the Pathogen Control Zone (see **Figure 22, page 219)**, will be on land that is hydrologically remote from the CVA and Shaft 12, and will be justified on the basis of meeting secondary objectives for biological diversity (early successional habitat creation) or to address a silvicultural concern. These larger openings must also be proposed within reasonable constraints on slope, soil and forest types, and will have additional public notice and review before implementation. The specifics of these proposed larger openings will be reviewed internally each year, as a component of the annual internal review of proposed harvesting (see Section 5.2.7).

By GIS analysis, the breakdown of DWSP properties by zones within the manageable portions of the Quabbin Reservoir watershed is shown in **Table 41.**

Table 41: Acres by Management Zone

Area	Acres	% of Total	% of Manageable
Total Quabbin DWSP holdings	58,412	100.0	NA
Areas with Special Management Restrictions			
Islands	3,674		
Steep slopes	1,712		
Wetlands	2,272		
Pottapaug Natural Area	1,183		
Quabbin Park (western portions)	1,058		
Others (cultural, rare species habitats, etc.)	1,837		
Total Areas with Special Management Restrictions	11,737	20.1	0.0
Manageable Area			
Manageable area in Zone 1	7,933	13.6	17.0
Zone 2, the Intake Protection Zones	2,563	4.4	5.5
(Zone 1 areas *within* Zone 2)	(734)	-	-
Manageable area in Zone 3	36,179	61.9	77.5
Total Manageable Area	46,675	79.9	100.0

5.2.3.5 Protection Provided for Water and Wetland Resources by Zones

Water and wetlands are the most important resources on drinking water supply watersheds. The zoning strategy outlined in Section 5.2.3.3 is designed to provide exceptional protection for these resources on the Quabbin Reservoir watershed. This protection is provided by overlapping policies, and in summary provides the following:

1. Tree harvests will not exceed 25% of any given subwatershed in any given 10 year period in order to protect against undesirable increases in water yield and associated increases in sediment and nutrient transport.

2. A minimum fifty foot filter strip will be maintained along all water bodies and vernal pools, as provided by Chapter 132, in which harvesting is limited to 50% of the basal area. As Quabbin Reservoir is an Outstanding Resource Water, this filter strip is of variable width, increasing with slope along the edge of the reservoir and all tributaries to the reservoir.

3. All stream crossings within 1,000 feet of the reservoir will use a portable bridge, as required by Chapter 132. A "stream" for these purposes is defined as "a body of running water, including brooks and creeks, which moves in a defined channel due to a hydraulic gradient, and which flows within, into, or out of an area subject to protection under the Wetlands Protection Act…Such a body of running water, which does not flow throughout the year (intermittent) is a stream except for the portion up-gradient from all bogs, swamps, wet meadows, and marshes." The Division furthers this protection by committing to cross all flowing water, regardless of its location or permanence, on a portable bridge so that even intermittent streams that are up gradient of wetlands will be crossed using a bridge if they are flowing or are likely to flow during the time that the work is being conducted.

4. Cutting practices and opening sizes will be restricted in areas of the Division's Zone 1 that are within 400 feet of the edge of the bank of the reservoir and 200 feet of the edge of the bank of all tributaries to the Reservoir. The minimum expression of this zone is shown in **Figure 14**. The Division recognizes that the mapping data used to define the area covered by DEP Zone A (and therefore, the Division's Zone 1) has missed some significant tributaries that flow to the reservoir.

This map, and its application in the field, will be subject to interpretation. A significant tributary that is not shown on the map will still receive the protection provided by Zone 1. An intermittent stream that is not shown will be protected according to Chapter 132 and the Division policy regarding stream crossings.

5.2.3.6 Species Composition Objectives

5.2.3.6.1 Diversity of Species Composition

The current species composition for the Quabbin forest is described in Section 2.4.2. The dominant species in the overstory of this forest are white pine and red oak, and the top ten species are shown in **Table 42**. There is no current plan to deliberately alter this landscape level species composition, with the exception of red pine, which occurs on the watershed due to planting rather than through natural regeneration and is frequently susceptible to the root rotting fungus *Heterobasidion annosum* (formerly called *Fomes annosus*). The Division has worked to replace red pine plantations with diverse natural regeneration of native species. As a result, the overstory stocking of red pine declined from 7.3% of the total stocking in 1990 to 2.8% of the total in 2000.

While there is no plan to deliberately alter the composition of the overstory (other than to reduce planted red pine), a number of changes in overstory composition are occurring naturally that will influence future composition. The Hemlock Woolly Adelgid, discussed in detail in section 5.2.4.1, arrived on the watershed within the past decade and is reducing the overall stocking of this species at a relatively rapid rate. The adelgid affects all ages of hemlock, from mature overstory trees to the youngest regeneration. Among other species impacts, white ash remains in decline as a result of a suite of pests. As the Quabbin forest has been maturing without catastrophic disturbance for many decades, the early successional species such as grey birch continue to decline.

Table 42: Top Ten Quabbin Overstory Species in 2000

Species	% of 2000 Stocking
White pine	28.2%
Red oak	19.6%
Red maple	13.3%
Hemlock	8.9%
Black oak	6.8%
Black birch	4.9%
White oak	3.8%
White ash	3.5%
Red pine	2.8%
Sugar maple	1.8%

In the most recent regeneration surveys for the Quabbin watershed, white pine dominated the understory trees species, with red maple and black birch also well represented across the watershed. The oaks were less abundant and are notoriously more challenging to regenerate successfully (it is well-established that the dominance of oak in the current overstory forest relates in part to the intensity of precedent land use disturbances, including fires and clearcutting, as well as lower deer pressures at the initiation of these stands). While the oaks are well-represented in regenerating stands, they are not as strong in the understory as they are in the overstory at Quabbin, a trend that is likely to continue due to a variety of difficulties in regenerating these species. Hemlock regenerates well, but the regeneration is as susceptible to the Hemlock Woolly Adelgid as the overstory. Protracted deer browsing impacts have resulted in a variety of challenges to replacing the current overstory. White pine and black birch each persisted in

areas with mildly elevated deer numbers and on large segments of the watershed they are likely to dominate the species composition there at least through the current rotation. This condition may also have consequences for water yield, due to the higher annual potential evapotranspiration of the conifers versus the deciduous hardwoods.

Allowing more options for group/patch size in zone 3 should enhance species diversity due to the greater variety of microclimate and shade conditions that can be produced with a greater variety of opening sizes. Shadows from overstory trees adjacent to forest openings can be very long for much of the day during the growing season. Therefore species requiring full sun for much of the day to compete well should benefit from larger openings and/or from orienting irregular-shaped openings to reduce shading (e.g., north/south rather than east/west). The number of native species in this region that compete best in full sun is greater than the number of species that compete best in partial sun.

In the past decade, a moose population has established itself at Quabbin and the effects of this population on species composition are locally apparent. In studies from areas other than Quabbin, moose have shown strong preference for red oak, red maple, hemlock, striped maple, black and yellow birch, ash, sugar maple, poplar, blackberry, and witch hazel. Once again, white pine is not preferred by this browser, so that as the moose population rises, white pine regeneration is likely to benefit further.

5.2.3.6.2 Species/Site Suitability

Species/site suitability incorporates the many environmental variables that determine how individual tree species regenerate and prosper, both by themselves and in the presence of other species. The science of *silvics* concerns itself with the environmental requirements of species. Most native trees in the Quabbin forest grow and compete on a wide range of sites, but to varying degrees of success. There are specific site conditions where each species grows best and sometimes different conditions in which that species will compete best against other species. For instance, while the most vigorous growth by white pine occurs on mesic, well-watered sites (often toward the base of hills), hardwoods also grow well on these sites and may out-compete white pine in the early stages. On drier, uphill sites, white pine grows moderately well and can out-compete the more moisture dependent hardwoods.

Quabbin soils are predominantly acidic in nature due to underlying granitic rock. Acidic soils support our most common trees: white pine, red and black oak, hemlock, and red maple. Trees that require more alkaline soils, such as sugar maple or basswood, are present but not common to this area. Soil moisture availability and soil drainage are also important factors in site suitability. The pines do well on well-drained soils, where these evergreens can capture moisture throughout much of the growing season with an extensive root system. Optimal conditions for white pine are well-drained sandy loam soils in river valleys with available moisture, three to four feet below the surface. The oaks do well on soils that are moderately well-drained and have moisture available for much of the growing season. Optimal conditions for oak occur on terraces at the base of steep slopes, where moisture and nutrients accumulate.

Site/species associations on the Quabbin landscape have been influenced, sometimes dramatically, by human land-use practices. The use of fire to clear land as well as fires started accidentally in the remains of past harvesting practices has favored the establishment of oak simply because it is among the species most capable of recovering (through vigorous sprouting) following fire. Tree planting that occurred in the 1930s and 1940s often placed non-native conifer species on sites where they would grow well (mesic agricultural fields), but where they also were more susceptible to such problems as *Heterobasidion annosum* (formerly called *Fomes annosus*) root-rot. Grazing practices left behind species that were not preferred by the grazing animals, but that might not be the native species best able to grow vigorously on these sites. There are vast acreages throughout New England of former grasslands into which white pine was able to establish seed and grow, but under conditions that favored the white pine weevil. As a result, the pine growing on these sites tends to carry a weak form caused by repeated weevil-kill of its terminal shoot.

It is an objective of Quabbin forest management to grow a vigorous, low-maintenance forest. This objective will be met more successfully as the species combinations growing on any given site are assessed for their suitability and, if necessary, moved toward more vigorous combinations. For instance, while DWSP has aggressively converted off-site red pine plantations to mixed combinations of native species, some of this type of conversion remains to be completed. Likewise, poorly formed white pine growing on old field sites will continue to be converted to mixed species combinations that are likely to persist longer in the face of both chronic and catastrophic stressors.

5.2.3.6.3 Water Use by Species

It is a goal of this management plan to maintain current water yields (see Water Yield Goals, Section 4.1.2). As the annual potential evapotranspiration rates are significantly higher for evergreen/conifer types than for hardwood/deciduous types, maintaining the current balance of these types will be important in meeting the goal to maintain current water yields. In spite of the conditions that favor an increased dominance of white pine in the regeneration of the next forest, it will be an objective of the Division to retain the current balance of evergreen overstory types versus deciduous types. At the present time, softwoods occupy 21% of the Quabbin forest, hardwoods occupy 47%, and mixed types occupy 25%. While white pine types may increase at the expense of some of the more difficult to reproduce oak types, this will be balanced by the conversion of red pine and hemlock types to mixed or hardwood composition.

5.2.3.6.4 Nutrient Control

Research indicates some variability among eastern US forest species in their ability to control nitrogen losses (Lovett, et al., 2002; Lewis and Likens, 2000; Christ et al., 2002). The carbon to nitrogen (C:N) ratio in and at the surface of the soil is important among the causes of these differences; a high ratio results in a high demand for N by soil microbes, so that nitrification rates are lower and the export of N off the site is less likely when the C:N ratio is high. C:N ratios relate predictably to overstory tree species composition in areas of the eastern U.S. For instance, C:N ratios in the Catskills in New York were higher under red oak and red maple stands than under sugar maple stands, and N export was higher from sugar maple stands than from red oak or red maple stands (Lovett, et al., 2002).

Studies in Eastern hemlock stands have indicated similar relationships. Hemlock produces an acidic duff layer as well as a cool, dark understory that in combination result in slow decomposition rates and a high C:N ratio. This high C:N ratio also supports low nitrification rates and low nitrate or cation export (Yorks, et al., 2000; Finzi, et al., 1998). Where mortality occurs in hemlock stands, temperature, decomposition, and nitrification rates increase; nitrification rates in gaps in the hemlock forest can be as high as twice those within the undisturbed hemlock forest (Mladenoff 1987). The conversion of hemlock to deciduous replacement types can result in an increase in pH and in mineralization/nitrification rates, as well as a long-term decrease in stored cations leached by nitrate and other anions. These changes are of particular concern where hemlock is growing adjacent to streams due to the increased possibility of moving nutrients into the stream water (Yorks, et al., 2000). Research has further shown that *Betula lenta* (black birch), which commonly regenerates beneath damaged hemlock stands, is capable of capitalizing on nitrate availability more efficiently than some other species (Crabtree and Bazzaz, 1993).

The Division recognizes that changes in species composition are brought about by a wide range of variables, and thus has not set rigid species objectives. The concern for long-term nutrient dynamics will nevertheless be a consideration in silvicultural practices that are likely to alter forest type.

5.2.3.6.5 Economic Value

Economic value does not directly influence a tree's value for water supply protection. However, the options for silvicultural treatment of these forests may be enhanced to the extent that the commercially more valuable species can be regenerated and grown. The commercial value of a particular species is

subject to the variations in consumer demand, although some species have remained relatively high in value for long periods of time.

White pine is a versatile species that is easy to use in a wide variety of commercial applications, is relatively easy to reproduce and grow, and can be produced in higher volumes on a given acreage than most other species. Red and white oaks are more difficult to regenerate, but have maintained a high market value until recently, and even recent declines leave the oaks still among the top species for value per board foot. Red maple has traditionally been a relatively low value species, sold primarily for fuelwood or pallet stock, but recent consumer preference for the light-colored hardwoods has significantly increased the value of sugar maple and even the better quality red maple. Most of the region's birches (paper, yellow, black) have traditionally sold to fuelwood or hardwood pulp markets, although the very best birches can be sold to the veneer market, where the clear-faced logs are peeled to make birch-veneered cabinets. Black birch can command high prices when individual stems reach veneer log dimensions without degradation. The frequent occurrence, however, of the *Nectria* fungal canker results in damage to the tree that prevents it from reaching full potential value.

Hemlock has grown well in the Quabbin forest, but has not generally commanded high prices, although the demand for hemlock as pulp increased significantly during the past decade. The Hemlock Woolly Adelgid has increased the volumes of hemlock sent to market, which can further depress market value as landowners rush to salvage value from threatened stands.

5.2.4 Implementation of the Forest Management Approach

Zones 1, 2 and 3 have been identified and mapped, as well as most subwatersheds. As mentioned above, there are forest management limitations imposed by the zoning scheme to help protect water quality but these zones do not provide specific harvesting locations. Our goal is to regenerate 10% of the managed forest over the next 10 years, distributed throughout all three management zones. The decision on which 10% will be regenerated and which 90% will not be regenerated will be based primarily on stand conditions For administrative purposes, Division holdings on the Quabbin watershed have been divided into five management blocks. These blocks will be divided into 20 -50 working units per management block. The management units in north Quabbin will use existing compartments as working units (there are currently 93 compartments averaging 580 acres in size at Quabbin). The management units in south Quabbin will be divided into 20 to 50 working units, delineated by streams, roads, stone walls or other permanent features. Each management block is about 12,000 acres and is treated as a separate sustainable unit. . Within the next 10 years, the working units/compartments within each block will be divided into stands and inventory data will be collected on these stands. Each working unit/compartment and all stands within those working units/compartments will be visited on ten-year intervals. Stand examinations will be conducted on these visits and the data collected will be used to prioritize stands needing silvicultural treatment. These data will be entered into a database to create long term profiles of stand and forest level change to augment the CFI system. Data collected for each stand will include:

- relative stand density (basal area - high, medium, low for stands of this type)
- stand height (20' ht classes)
- forest type
- stand age (20 yr age classes)
- regeneration type and adequacy
- relative stand condition (vigor/quality - high, medium, low)
- special features (unique habitats, vernal pools, significant forest and wildlife features)

Silvicultural activities will be dispersed across the watershed to enhance diversity and aesthetic amenities by following a sequential pattern. Working units will be numbered one through n (n=number of units for this management unit). Each year about 10% of the working units/ compartment will be examined, starting the first year with compartments/ units 1,11,21,31,41, etc., with 2,12,22,32,42, etc., examined the second year, and so on until the entire forest has been covered. This planned pattern may be disrupted by the need to address pest or weather disturbances, but will generally dictate the areas to be treated.

Priorities for treatment will be set using stand examinations in each year's working units/compartments. To achieve a diverse age structure, about 1% will be cut in each zone each year. This may vary from year to year but will equal 10% after ten years.. Over time, this cutting regime will begin to balance the age structure of the forest in these areas, adding resistance and resilience to the forest cover.

Stands within zones 1, 2 or 3 will be prioritized for silvicultural work as follows:

- lack of species and or structural diversity (i.e., plantations or native single-species stands)
- high risk of stand not surviving another 10 years (e.g., insect and disease problems)
- low vigor/low quality trees occupying the growing space
- undesirable non-native species
- stands with advance regeneration in place requiring release
- stands with rapidly declining overstory trees

While approximately 12,000 acres will be designated as unmanaged areas within the Division's holdings surrounding Quabbin Reservoir, the remaining 46,000 acres will be actively managed to maintain resistance and resilience through deliberate improvements in age and species diversity within any given subwatershed. The silvicultural disturbance of these managed areas will reflect the average rate of natural disturbance in these forests, which ranges from approximately 0.5% to approximately 2.0% per year (Attiwill, 1994), or approximately 1.0% per year on average. To meet this objective, approximately 1% or approximately 400-450 acres of the managed forest will be regenerated annually, on average, during the next 10 years.

5.2.4.1 Silvicultural Practices

Forest management activities during the period covered by this management plan continue to emphasize the development of multi-aged or uneven-aged conditions on the majority of the managed area of approximately 46,000 acres. Uneven-aged stands are defined as those that contain at least three distinct age classes, differing in total height and age (Smith, et al., 1997), and managed on cutting cycles that enable established regeneration to be released sufficiently to be free to grow as new age classes. Uneven-aged silviculture, focused primarily on small-group selection, tends to favor shade-tolerant and mid-tolerant species. In order to regenerate the less tolerant species, and to provide a more varied forest structure across the landscape, the plan also accommodates patch cutting, in which opening size and shape provide conditions in some portion of the opening that are outside the influence of the mature trees on the edge of the openings (generally when the opening is at least twice as wide as the height of the tallest surrounding trees, although this will vary with slope and aspect). The combination of methods that includes patch cuttings supports a range of species and ages that may not strictly follow the definition of uneven-aged structure, and is referred to instead as multi-aged structure. While sustainability is often measured by the balance between growth and harvest, the silvicultural objective for the management of the watershed protection forest is primarily driven by the need to provide long-term protection for water quality, rather than the need to produce an optimized, consistent flow of wood products.

2-year post harvest multi-aged structure developed via small group selection on Prescott Peninsula

5.2.4.1.1 Regeneration methods

The proposed regeneration silviculture for this ten-year management period at Quabbin will consist primarily of small group and patch selection cutting. Regeneration establishment may also be encouraged through limited "enrichment" planting if necessary. So long as herbivore pressure and competing native or exotic vegetation are kept under control, regeneration establishment is generally very successful in the Quabbin forest. Seed sources are diverse and frequently prolific, and regeneration monitoring shows high numbers of seedlings established on the forest floor with few exceptions. In the few cases where this natural regeneration has been impaired, a limited amount of

Recently harvested small group selection and patch cuts, New Salem block

planting may occur to enhance the diversity and/or the density of the seedling pool (enrichment planting during 1995-2005 is summarized in **Table 44**).

The majority of the harvesting that will take place at Quabbin over the next decade will be made to release regeneration that has become established in the understory or will become established within 5 years , thus developing new age classes capable of persisting to mature overstory trees. Advance regeneration will not be required on all lots due to the relatively small average opening sizes proposed in this plan. Seed sources are abundant in most of the forest and the proposed openings provide environmental conditions that allow a diversity of regeneration to become established in a short time period on most sites.

The overall DWSP silvicultural objective remains focused on the development of a multi-aged forest for water supply protection, with age diversity ranging from multi-aged or uneven-aged conditions in stands where small group selection cutting is the chosen silvicultural method, to primarily even-aged conditions on the limited number of small stands that are regenerated with patch cuts greater than two acres. The general distinction between a "small group" and a "patch" revolves around the influence of edge trees over regeneration within the opening. Where the shape and size of the opening retain the influence of the surrounding trees, it is considered a small group. Where portions of the opening are beyond the influence of the surrounding trees, it is considered a patch. Small groups may be as small as the area released by cutting a single large tree, or as large as two acres if the cut area is relatively narrow in shape.

In timber sales where the average size group is under ½ acre, all groups will be estimated to the nearest 1/10 acre and all groups over 1/10 acre will be measured using GPS units. In timber sales where the average opening size is ½ acre or more all groups/patches will be estimated to the nearest ¼ acre and all groups over ¼ acre will be measured using a GPS unit. Residual basal areas under 10sqft will be ignored when calculating regeneration acres. In areas that lack regeneration, shelterwood and seed tree type cutting will be an option provided the seed cuts are not larger than the allowed opening size for the zone in which the cutting takes place.

Table 44: Enrichment Planting of Tree Seedlings, 1995 - 2005

Year	Red Oak	White Pine	Norway Spruce	Red Pine	Sugar Maple	White Ash	White Oak	Hemlock	Others	Total
1995	5,900	20,000	10,000	0	2,600	6,600	0	0	0	**45,100**
1996	10,000	33,000	0	3,000	0	0	0	2,000	0	**48,000**
1997	14,000	10,000	0	0	2,000	0	1,500	0	0	**27,500**
1998	13,000	9,000	0	0	2,000	0	1,000	0	0	**25,000**
1999	21,000	0	7,500	0	0	0	1,500	0	0	**30,000**
2000	20,000	23,000	0	0	0	0	0	0	0	**43,000**
2001	300	4,000	2,000	2,000	280	0	0	0	500	**9,080**
2002	6,000	2,000	2,000	2,000	0	0	0	0	300	**12,300**
2003	11,500	5,100	4,000	4,000	0	0	0	0	0	**24,600**
2004	5,000	0	0	6,000	0	0	0	0	0	**11,000**
2005	NO SEEDLINGS PLANTED									**0**
Total	**106,700**	**106,100**	**25,500**	**17,000**	**6,880**	**6,600**	**4,000**	**2,000**	**800**	**275,580**

5.2.4.1.2 Post Harvest Monitoring of Regeneration Cuttings

Many things influence the outcome of regeneration cutting. Site conditions such as shade, soils, aspect, seed sources, forest floor disturbance, or advance regeneration can have some impact on the desired regeneration. Herbivores such as moose, deer, and beaver as well as insects, diseases, weather conditions, and fire can also have very serious impacts on regeneration. Because many of the things that can

influence the outcome of regeneration cutting are constantly changing, it is often difficult to predict in advance what their impact on regeneration will be several years after the harvest. In order to keep up with and adjust to these potential effects on regeneration success, all timber sales involving regeneration cutting will be inventoried 2 -5 years after harvesting. At this time our greatest concern is the impact of moose on regeneration; methods are under development to quantify this impact.

5.2.4.1.3 Intermediate Cuttings

Intermediate cuttings are performed on stands prior to maturity. They are designated as "thinnings" when the objective is to remove trees of low vigor thereby decreasing competition within the stand and increasing the vigor and growth rate of the remaining trees. "Improvement" operations are designed to adjust the species and quality composition of stand. In fact, virtually all intermediate cuttings are a combination of both thinning and improvement. The defining characteristic of all intermediate operations is that there is no intention regarding the establishment or encouragement of regeneration. However, because the age structure at Quabbin is predominately older, maturing stands, it is difficult to avoid a regeneration response after an intermediate cut. If the regeneration that becomes established after an intermediate cut is not released within 10 years, intermediate thinnings will favor the more shade tolerant regeneration on many sites. In order to reduce the potential future impacts on species diversity (predominately shade tolerant species) we have reduced the amount of this type of cutting at Quabbin. As the age structure of the Quabbin forest changes to include more trees in the 20 to 60 year old age classes, the amount of intermediate treatment may increase.

Due to the relative scarcity of purely pole-sized stands on Division property at Quabbin, intermediate cuttings are rarely performed as the sole objective. Most intermediate operations are performed simultaneously with regeneration cuts, especially in stands that are being treated for the first time without the benefit of prior or recent management or those that have not been treated for many years. During the next ten years, intermediate cuttings may occur on up to 200 acres per year.

5.2.4.1.4 Riparian Zone Management

The most common riparian zone management strategy land managers take in a variety of plans and Conservation Management Practices is simply to leave these areas alone. In fact, this strategy has the force of law in many states, as a component of wetland protection or timber harvesting regulations. MGL Ch. 131 (Wetlands Protection Act) and Ch. 132 (Forest Cutting Practices Act) both contain language that restricts activities within riparian zones. The assumption behind these regulations is that manipulations of these zones will degrade the critical buffering capacity of these areas and may result in soil disturbances that are more likely to result in sediment transport into streams. Studies show, however, that it is the activity associated with removing trees that is associated with these impacts, not the act of cutting them. DWSP recognizes these zones as the final and therefore most critical opportunity to slow or capture nutrients and sediments released by the variety of natural and human-caused events on the watersheds,

Lower reaches of Underhill Brook

and therefore does not categorically exclude them from management.

The preferred vegetative structure of riparian zones is an actively growing, diverse, self-perpetuating, and disturbance-resistance forest cover. Carefully planned and implemented human intervention may be the best method to maintain this forest structure throughout the variety of disturbances that impact all New England forests. To some degree, when these forests are within the bottom of stream and river valleys, they may be sheltered from winds. However, as riparian forests mature, and especially when they are in the path of destructive storms, they become vulnerable to sudden and dramatic change. When wind-throw or flooding occurs, it is of great concern to watershed managers because it can result in substantial amounts of soil and nutrient transport. Additional concerns include sudden changes in stream temperatures due to loss of forest cover and heavy accumulations of woody debris and sediments when trees fall directly into streams or the streams are dammed.

The most important source of resistance and resilience to build into the riparian forest is the establishment of regeneration. This regeneration serves to anchor soils following disturbances, resists damage from many disturbances (due to size and density), and shortens recovery times for reestablishing riparian forest following most disturbances. Riparian forest that is simply left alone may establish sufficient regeneration as the overstory begins to age and decline in vigor. However, where full crown closure is maintained for long periods of time (especially in hemlock stands), understory development will be limited by low understory light and thus there will be delays in recovery following major disturbances. Through carefully implemented manipulations of the overstory and understory, DCR managers intend to systematically "condition" certain vulnerable riparian forest to be better able to maintain their critical buffering functions throughout significant disturbances.

Directional felling of small groups and individual trees, without removal, may be done to bring light to the understory where soft soils prevent equipment of any size. Trees will be felled perpendicular to the prevailing slope and cut into sections so that trunk comes in contact with the ground to enhance the debris and sediment trapping capabilities of the riparian zone. Felling will not be done into streams. It has been demonstrated that the natural fall due to individual tree mortality (as opposed to catastrophic events) will add sufficient material in streams to create beneficial debris dams.

5.2.4.2 Silviculture by Forest Type

The principal forest types on Quabbin are described below, with a brief description of silvicultural approaches applicable to each type within the context of watershed management. These types may occur as pure stands, or more often as mixed forest with either gradual or sharp type changes related to soil types, aspect and elevation, and past land use history. **Table 18** in section 2.4.2.1 above provides details on all types and subtypes from the most recent aerial photo and field interpretation.

1) Oak Types

Red, black, scarlet, white, and chestnut oak comprise the five major species in this type, with red oak generally the most vigorous, dominant component. The type grows best on the more fertile, moist, moderately well-drained sites. Because of its superior vigor, red oak will be favored where moisture is sufficient to support its growth. While Quabbin is host to some of the largest contiguous oak stands in the Northeast, it is important to recognize that these stands were established through dramatic clear-cutting and burning, landuse practices of the past that were tolerated better by oaks than by most other competing species. Regenerating red oak through more conventional silviculture has been difficult, especially as these are desired species for browsing ungulates (deer, moose). It is likely, therefore, that the multi-aged silviculture proposed by this plan will ultimately result in the replacement of these oak stands with a wider diversity of species. While this replacement may compromise other values of these contiguous

stands, such as hard mast (acorn) production, it supports the Division goal of increasing species diversity to improve stand resilience.

Scarlet and black oaks are plentiful on some well-drained upland sites (where lack of moisture limits red oak) but are generally of poor vigor. Gypsy moth infestations in the past have been most severe on these drier sites. Consequently, efforts have been made to increase the component of other species on these uplands, e.g. by salvaging dying oaks and underplanting with white pine in the resulting openings. White pine survives and grows well on these sites and the majority of these black and scarlet oak stands will eventually be converted to mixed stands of oak, white pine, and other species.

White oak, like black and scarlet oak, is also found growing on dry upland sites. However, it exhibits its best growth on moister soils. The acorn of the white oak is less acidic than that of the other, more abundant oak species, and consequently more valuable to wildlife. On the Quabbin watershed, white oak was a primary host to the gypsy moth and, due to physiological differences, suffered more severe mortality than the red oaks. White oak that is surviving and growing vigorously will receive preferential treatment in order to maintain the species as a component on the watershed.

Chestnut oak is primarily found growing on the poorest of upland sites on southern and eastern exposures in shallow soils, especially inside of Route 202. North of Route 202 in the West Branch of the Swift River, chestnut oak was commonly found growing with red and white oak. However, gypsy moth infestations of the early 1980s eliminated most of the chestnut oaks from these stands. Regeneration of chestnut oak has been successful where deer pressure has been reduced by hunting. Because this species occurs in relatively few sections of the watershed, it is desirable to maintain it where possible as the major component of a mixed stand as opposed to aggressively converting these sites to white pine.

2) White Pine Types

White pine is among the fastest growing species in the region and responds well to management. It is found most often on dry, sandy sites where hardwoods do not grow well or in abandoned pastures and fields where its heavier seed was capable of penetrating the thick grasses more successfully than hardwood seed (Spurr and Barnes 1980:444). White pine grows most vigorously on moist sandy and silty loams, but it is difficult to establish on these sites because of hardwood competition. Where deer browsing levels have been moderate, there are moist sites where white pine has become established on moist sites due to preferential browsing on hardwoods. These areas will eventually support a more mixed composition, but will tend toward white pine for the next generation.

Most of Quabbin's white pine stands are 65 to 100 years old, the result of natural seeding in old, abandoned pastures and fields, vestiges of stands damaged during the 1938 hurricane, and remnants left over from silvicultural operations prior to DCR ownership. White pine that becomes established in low densities in abandoned pastures is often exposed to repeated white pine weevil infestation. The resulting multiple-leader crown is often more susceptible to wind and ice damage and subsequent fungal invasion than high-density, forest-grown white pine.. Where these occur as isolated trees, they do not constitute a risk to watershed cover maintenance. However, where they comprise the majority of a stand, their gradual removal and replacement with understory trees that will develop a stronger form is desirable.

Some of the Quabbin white pine component is within plantations established in the 1930s and 1940s. Many of these plantations were planted as a mix of red and white pine. The sites chosen were often moist, rich agricultural sites, where red pine grew much more vigorously than white pine. In addition, these moist sites correlate with high infestations of the white pine weevil. As a result, much of the white pine that has survived in plantations is suppressed beneath the red pine, and shows signs of repeated

weeviling. Intermediate cuts in the few remaining mixed pine plantations will continue to preferentially remove the white pine.

3) Red Pine Type

Red pine is an uncommon native species in this area, but was successfully established, in conjunction with planted white pine, on approximately 2,750 acres on the Quabbin watershed during the 1930s and 1940s. Red pine is capable of growing well on a variety of sites, but is most stable on moderately well-drained, sandy loams, where root depth is less limited. On the more moist and fertile sites, red pine has grown to a total height of 90 feet and a diameter at breast height in excess of 24" within 50 years from planting. However, it is on these same sites that red pine has exhibited susceptibility to root rot disease (*Heterobasidion annosum*, formerly called *Fomes annosus)* and to wind throw. For watershed purposes, it has therefore been an objective for more than a decade to convert these sites to a more reliably stable cover of mixed native hardwoods. This conversion was aggressively promoted during the previous management period, and many of these susceptible stands have been successfully converted. Where root rot diseases have killed more than scattered trees, sanitation clearings will continue to be conducted in remaining moist-site red pine plantations, both to halt the spread of the disease (which passes from tree to tree through root grafting) and to hasten the conversion to site-suited species.

4) Birch/Red Maple Type

Black and paper birch, as well as red maple, will occur as pioneer species on many sites, but this overstory type is generally found growing only on moist sites, where red maple is usually the dominant species. While it tolerates these sites better than most species in the establishment phase, maturing red maple is quite susceptible to heart rot where soil drainage is slow. Generally, the black and white birches that establish successfully in these areas do not thrive beyond about forty years of age. Black or sweet birch is particularly susceptible to *Nectria* canker, and paper birch in these areas may develop red heart, a fungal complex. Both the stems and branches of the birches are damaged easily by ice and heavy snows.

In some cases, birches dominate the overstory because they were a less preferred deer browse in early stages of succession, or were able to outgrow livestock grazing on pasture sites. The same browsing/grazing pressure apparently prevented later successional stage components, such as oaks, ashes, sugar maple, and hemlock, from replacing the pioneers. Where there are scattered stems or small groups of more long-lived species, intermediate cuts will favor their growth and development as seed sources. Where long-lived species are missing, regeneration cuts will reestablish more comprehensive stand development.

5) Hemlock Type

Hemlock grows most often in cool moist areas along brooks and streams and on north-facing slopes, but is also found on a wide variety of other sites. Hemlock stands are generally the best winter deer cover on the watershed and have been heavily browsed. As a result, hemlock regeneration has been extremely limited across the Quabbin Reservation. While gypsy moth and the hemlock looper have attacked individual trees or stands for many decades, their impact pales compared to the devastating impact of the hemlock woolly adelgid. See section 5.2.4.1 for much greater detail on this pest and the agency's forest management response.

Due to these pressures on the species, the majority of silviculture within the type during this decade will be salvage operations and scattered intermediate cutting to maintain vigor and seed-producing capabilities. However, where diversification of vertical structure within hemlock stands is desirable,

regeneration cuts may be conducted within the constraints of the current hemlock woolly adelgid management policy.

6) Spruce Type

The majority of the spruce trees growing at Quabbin were planted in the late 1930s and early 1940s. Norway, red, and white spruce were planted. While some of the Norway spruce plantations have grown very well (in particular, on Prescott Peninsula), the red and white spruce generally did poorly. Approximately 500 acres of spruce plantations survived establishment. Limited silviculture was conducted in these stands during the past decade, taking advantage of the ability of mechanized harvesting equipment to fell and process the typically limby stems within these dense, generally unthinned plantations. Markets have been fairly strong for this species in recent years. These improved opportunities will be utilized to create additional forest layers as needed in these uniform stands. Spruce regeneration has been most successful in more open conditions and efforts will be made to gradually enlarge existing openings and create new openings to perpetuate this unusual component of the forest.

There is evidence in the literature that some of the spruces are among the best choices of species for wind tolerance. Spruce wood is generally quite strong relative to other conifers, and its stem tapers very slowly, increasing resistance to breakage. Spruces cones are well-utilized by a variety of wildlife. Black spruce is also particularly tolerant of wet conditions and an appropriate plant for revegetating deforested riparian areas. For all the above reasons, spruce will be among the species considered for planting in wetter riparian areas.

7) Northern Hardwoods

Northern Hardwoods include sugar maple, black and yellow birch, beech, and white ash growing on fertile sites on thick, moist, moderately well-drained, fine, sandy loams. Although they have survived insect attacks, dieback, acid deposition, and increased ozone concentrations, the perpetuation of these stands has been most heavily influenced by wildlife impacts. Seeds that manage to escape animal consumption and germinate into seedlings, with the exception of black birch and beech, were browsed heavily by deer during the previous decade. Because this type often grows in the moist bottomlands, mature trees are often girdled or felled by beaver, especially where deer browsing has eliminated other food sources. While there are a few pure stands of these species, they are usually found scattered throughout other types and will receive preferential treatment over most other species, due to their rare occurrence.

5.2.4.3 Summary of Planned Silvicultural Activities

The following summarizes the silvicultural strategy to be applied in the Quabbin forest over the next decade:

1. The total holding is ~58,000 acres, ~12,000 of which are unmanaged (islands, wetlands, steep slopes, designated natural areas), so that approximately 46,000 are considered manageable. As areas are assessed for management, small reserves from a few trees to multiple acres will be added to the unmanaged category, which may rise to 25% or more of the total holding as a result. The overall (and continuing) objective is to diversify age structure in the managed area by regenerating approximately 1% annually, or about 400 acres. This cutting will be restricted in several ways, described below.

2. DWSP will not regenerate more than 25% of any given subwatershed within any given 10 year period (this is an application of the results from research on paired watershed studies, which

conclude that with Conservation Management Practices (CMPs) in place, there is generally no increase in water yield, which in turn implies no increase in sediment or nutrient transport, until 25-30% of a watershed forest's basal area is cut within any given 3-10 year period (Ice and Stednick, 2004)).

3. Silvicultural practices will occur within three management zones:
   a. **Zone 1** includes the buffer strips along public roads, the variable width filter strip along streams and water bodies, and DWSP limits within filter strips around all vernal pools, and the area within 400 feet of the bank of the reservoir or within 200 feet of the bank of a tributary to the reservoir.
   b. **Zone 2, the Intake Protection Area** includes two protection areas, around the CVA and Shaft 12 intakes. For the CVA, this zone includes land within the watershed that is within ½ mile of the reservoir portion of the Quabbin Pathogen Control Zone. For the Shaft 12 intake, this Intake Protection Zone is the land that is within ½ mile of the intake, but also no further east than the watershed divide that sheds water either to the west or the east of the south baffle dam. The CVA Intake Protection Zone includes 2,435 acres, 695 of which are also in Zone 1. The Shaft 12 Intake Protection Zone includes 128 acres, 39 of which are also in Zone 1.
   c. **Zone 3** is the land that is outside Zones 1 and 2 and hydrologically most remote from the reservoir and intakes. This zone covers ~36,000 acres, or about 77% of the manageable area.

4. Cutting will be limited in all cases as follows:
   a. Zone 1 – single tree or small group selection up to 0.5 acre
   b. Zone 2 – single tree, small group, and patch selection up to 1 acre in size
   c. Zone 3 – single tree, small group, and patch cutting, with the majority in a diverse mix of groups and patches under 2 acres in size and a maximum of 10% of the total annual cutting (no more than 40 acres) in larger openings greater than 2 acres in size.

5. Cutting will be further limited as follows:
   a. Each year, at least 90% (360+ acres) of the regeneration cutting will be in single tree or small group selection harvest less than 2 acres in size, and completed within Zone 1 (single tree selection and small group selection up to 0.5 acre only), Zone 2 (single tree selection and small groups not larger than 1 acre), and Zone 3 (single tree selection and small groups with a target size of 1 acre or less, but not larger than 2 acres).
   b. In response to green certification recommendations that structural diversity at the landscape level should include some larger single-aged blocks and concerns for declining migratory birds and other species that require early successional habitat and certain silvicultural situations, each year up to 10% of the regeneration cutting will be in patches greater than 2 acres in size and completed within Zone 3 only.

6. In addition, up to 200 acres of intermediate thinnings will occur each year where necessary to increase group or stand vigor.

5.2.4.4 Comparison of Forestry in the 1995-2004 versus the 2007-2017 Quabbin Land Management Plans

- In the 1995-2004 Land Management Plan, the vast majority of the regeneration cutting was concentrated in small groups ranging up to 1 acre in size. The proposal was to regenerate 500-600 acres per year during the 1995-2004 management period; 388 acres per year were actually regenerated on average, plus 640 acres of preparatory or intermediate cutting. That plan allowed full overstory removal in special cases (red pine on disease-prone wetter sites; old grazing areas

with low species diversity; and old field white pine stands with very poor form and vigor), and limited this type of cutting to a maximum of 50-60 acres of the managed forest annually.

- The current plan calls for regenerating 400 to 450 acres annually, still primarily in openings from single tree to about 2 acres in size, and with options to create larger openings where the site is hydrologically removed from the Reservoir and where these can be justified for silvicultural reasons or to enhance horizontal diversity in support of uncommon species. This target acreage would annually regenerate about 1% of the managed forest area during the coming decade. Openings larger than 2 acres would not total more than 10% of the annual regeneration cutting (not more than 40 acres per year). Intermediate thinnings are proposed on up to 200 acres annually.

- The proposed 2007-2016 LMP is a continuation of the overall strategy of diversifying the forest structure, but includes a stronger correlation between harvesting and hydrologic sensitivity through an on-going analysis of the percentage of any given subwatershed that has been treated in the previous decade, and through the establishment of the hydrologic zoning system described in Section 5.2.3.3.

Table 43: Harvesting at Quabbin Fiscal Years 1996-2005

Fiscal Year	Total Acres Harvested	Total Acres Regenerated	Board Feet	Cords	Tons	Revenue
1996	659	85	2,645,494	1,994	3,458	$306,048
1997	1,274	682	7,447,357	3,495	9,215	$727,993
1998	1,253	385	4,894,431	4,908	1,569	$677,017
1999	1,332	382	5,327,581	4,974	7,410	$567,504
2000	1,110	419	5,042,700	3,884	6,221	$1,028,977
2001	745	371	4,532,600	2,703	8,059	$524,075
2002	808	380	4,196,880	2,646	7,665	$571,601
2003	1,003	397	5,575,799	4,150	8,645	$704,882
2004	890	337	2,873,334	4,095	5,170	$381,540
2005	1,205	439	5,146,694	5,598	6,864	$757,708
TOTAL	**10,279**	**3,877**	**47,682,870**	**38,447**	**64,276**	**$6,247,345**
Average	*1,028*	*388*	*4,768,287*	*3,845*	*6,428*	*$ 624,734*

Table 44: Example of a *Possible* Cutting Pattern during FY 2007-2017, by Forest Management Zones

Type	Zone 1	Zone 2	Zone 3	TOTAL	Percent of type total
Regeneration cuts	*Acres by Treatment Type*				
Single tree	50	10	15	75	18.75% of regen cuts
Small groups to 0.25 acre	20			20	5.00% of regen cuts
Small groups to 1 acre		10	185	195	48.75% of regen cuts
Small groups to 2 acres			70	70	17.50% of regen cuts
Patches 2-5 acres			20	20	5.00% of regen cuts
Patches 5-10+ acres			20	20	5.00% of regen cuts
Total regeneration cuts by zone	*70*	*20*	*310*	*400*	
Intermediate thinnings	35	10	155	*200*	
Treatment totals	*105*	*30*	*465*	*600*	

5.2.5 Current Threats: Forest Insects, Diseases, and Invasive Exotic Plants

In the Quabbin forest, insects and disease are a major problem only when their impacts conflict with the Division's objective of creating and maintaining a watershed protection forest. Generally, only large-scale outbreaks that threaten to alter tree species diversity or forest structure are of concern. Chestnut blight was such a disease. It was first discovered in the Quabbin forest in the early 1900s and fairly rapidly eliminated all overstory trees of the species. Salvage of the dead and dying trees began immediately in the hope of protecting the yet uninfected chestnuts. Before the blight, chestnut was one of the dominant trees in the forest. Today, it is essentially a minor shrub, playing a much less significant role in the protection of the water supply and in support of biological diversity through its significant production of mast. Fortunately, both of these roles have been replaced by the now common oak component of the Quabbin forest.

The gypsy moth is another example of a serious pest. It was first found in the forest surrounding the Wachusett Reservoir in 1910. A great deal of effort was spent in trying to control the inexorable spread of this insect. Epidemics of this insect can result in significant mortality of a wide range of tree species in both the overstory and understory resulting in alterations to forest structure, composition and vigor. Insect defoliations have also been demonstrated to affect water quality. Research from North Carolina has demonstrated that concentrations of stream nitrate nitrogen were elevated 4-5 times background rates during peak defoliations by cankerworm (Swank, et al., 1981).

Both the fungus that causes chestnut blight (*Cryphonectria parasitica*) and the gypsy moth (*Lymantria dispar*) are introduced organisms that came to the watershed forests without their co-evolved complement of predators and parasites; a recipe for the development of an altered ecological condition. Other examples that have in the past affected or are currently affecting the Quabbin forest include Dutch elm disease, beech bark disease, and white pine blister rust. The most significant current threat to the Quabbin forest is the hemlock woolly adelgid, a pest for which the Division has developed the policy that follows in Section 5.2.4.1.

5.2.5.1 Hemlock Woolly Adelgid and DWSP Policy for Managing Impacts

Hemlock woolly adelgid, *Adelges tsugae*

The hemlock woolly adelgid (HWA; *Adelges tsugae*) is a small aphid-like insect native to Japan. It arrived in North America in the 1920s, and was first recognized on the east coast of the US in 1951 and in Connecticut in 1985. It is spreading in all directions across the range of eastern hemlock (*Tsuga canadensis*). It is a serious pest on both eastern hemlock and Carolina hemlock (*Tsuga caroliniana Engelm*), but does not seriously injure the western hemlocks (*Tsuga heterophylla* or *Tsuga mertensiana*). Chinese hemlock (*Tsuga chinensis*) planted at the Harvard University Arnold Arboretum resists HWA (Peter Del Tredici, Senior Research Scientist, Arnold Arboretum, personal communication).

Eastern hemlock grows throughout the watersheds under the care and control of DWSP, but is concentrated in three forest types: relatively pure hemlock stands; in mixes where white pine dominates; and in mixes where hardwoods dominate. Forest typing completed in the past several years indicates that out of the approximately 58,000 acres of Quabbin watershed forest that DWSP controls, 1,642 acres (~3%) is in pure hemlock stands; an additional 5,434 acres (~9%) is in stands with a significant component of hemlock in mixes with other softwood and hardwood species. About 9% of the overall basal area on Quabbin permanent inventory plots was in hemlock in 2000, and

hemlock sawlog volume based on those plots was approximately 30-35 MMBF. On DWSP properties on the Ware River watershed, about 7% of the overall stocking is in hemlock, the vast majority of which is in mixed white pine/hemlock stands, which total approximately 4,325 acres. A rough estimate puts the hemlock volume at Ware River in excess of 10 MMBF. Hemlock is <2% of the stocking, on just over 120 acres of hemlock/hardwood type on the Wachusett Reservoir watershed. A significant portion of the hemlock stocking overall is located on wet soils, on steep slopes, or in riparian zones, some of which are steep-sided ravines, while other stands are on drier and flatter terrain.

The hemlock woolly adelgid is a particularly troublesome pest on DWSP watersheds (and elsewhere) for several reasons:

1. The insect is without natural enemies in the northeastern US. Several potential biocontrols have been imported from Japan and China, reared in laboratories, and released at HWA sites, but to date these have had very limited impact for a variety of reasons. Successful chemical controls are mostly limited to systemics and dormant oil spraying. These can be effective in ornamental plantings, but are virtually impossible to apply in an extensive forest infestation.

2. The HWA is parthenogenic, which means that every adult is capable of reproduction. Each adult lays 50-300 eggs, typically about 100. Furthermore, the population successfully completes two generations within a year. The first eggs are laid in March and April. Crawlers hatch from these eggs and begin feeding at the base of needles, where they remain throughout development. This generation matures in mid-June, when adults lay eggs again. These hatch in July, move to new hemlock growth and then become dormant until October, when they begin feeding again. They continue feeding throughout the winter (the species evolved in high elevations in Asia and tolerates low temperatures), maturing by spring to begin the process again. Mortality rates observed during the winter of 2002-2003 were as high as 75% (Jen Pontius, USDA FS, personal communication), but the fecundity of this species will likely allow its rapid recovery.

3. While hemlocks that are under attack eventually become incapable of supporting the infestation, resulting in a population crash in the HWA on that tree, these trees are also incapable of recovering from this level of damage. Trees that are infected may die within 4-5 years, although some may persist for longer in a weakened condition. The insect attacks all ages of trees, though it prefers younger foliage. There is no clear evidence of resistance sufficient to allow any individual eastern hemlock tree to survive once infested with the hemlock woolly adelgid (Orwig et al., 2002).

4. Of particular concern to DWSP are location where hemlock dominates the riparian zone along streams leading to the reservoirs or the Ware River. Loss of this overstory may present short-term threats to water quality by raising stream temperatures and through uncaptured nitrogen and other cation losses following increases in nitrogen mineralization and nitrification rates. Regeneration may prevent significant losses to stream water.

5.2.5.1.1 Principle Issues From Current HWA Literature

1. All ages and sizes of Hemlock are susceptible to HWA infection, and infection will eventually kill the infected tree. Trees on poorer, drier, ridge top sites may die more rapidly than those on well-watered sites, but trees located on the full range of sites have become infected and ultimately died.

> Mortality was weakly related to aspect and stand size. Average mortality was highest on western aspects but exceeded 20% on most slopes. Remaining trees averaged over 50% foliar loss, with no significant

> difference among aspects… Results suggest that as HWA becomes abundant, stands on xeric aspects succumb rapidly, but that stand and landscape variables such as overstory composition and structure, slope, and elevation, exert little control over susceptibility or eventual mortality. (Orwig et al., 2002)

2. All approaches to management, including simply allowing HWA mortality to occur without intervention, result in changes to the forest floor that include increased mineralization and nitrification rates that produce more mobile inorganic nitrogen. To the extent that regeneration occurs in pace with, or in advance of mortality, available inorganic nitrogen is recaptured and immobilized by biomass accumulation. Consequently, it should be expected that the highest accumulation of inorganic nitrogen will occur in soils where heavy cutting occurs with little or no regeneration on the ground, while the more gradual conversion associated with either partial, preparatory cutting designed to stimulate advance regeneration or letting the stand die and regenerate without intervention should reduce both the volume and the duration of soil accumulations of inorganic nitrogen. The significance of these differences in soil nutrient accumulations to quality changes in adjacent surface waters is uncertain.

> The total amount of N captured in recent harvests was about five times greater than HWA-damaged [unharvested] sites and nine times greater than undamaged sites….Compared with undamaged sites, inorganic N pools increased only slightly in HWA-damaged sites, but increased tremendously following logging.…Net nitrification rates were 41 times higher in HWA-damaged sites, 72 times higher in recent harvests, and over 200 times higher in old harvests when compared with the near-zero rates in undamaged hemlock sites.…Relatively large amounts of ammonium and nitrate captured in recent harvests indicate higher N availability, less vegetative uptake, and a greater potential for N leaching. Hemlock harvesting imposed more abrupt microenvironmental changes, and rapidly reduced vegetative cover while chronic HWA infestation led to gradually thinning canopies. Both disturbances led to black-birch dominated forests, although logging resulted in greater amounts of shade-intolerant regeneration, higher soil pH and nitrification rates, and reduced forest floor mass. Pre-emptive cutting of undamaged forests may lead to greater N losses than those associated with HWA infestation or logging of deteriorated hemlock forests, because of reduced vegetative uptake. Silvicultural methods that allow for vegetation establishment prior to harvesting will probably lessen the ecological impacts of hemlock removal.…We predict in sites infested with HWA, the slow and progressive hemlock decline and gradual development of a hardwood understory may result in the least amount of nitrogen loss. Pre-emptive cutting of undamaged sites appears to pose the greatest threat for nitrate leaching, followed by logging of declining sites. (Kizlinski, et al., 2002)

> There is clearly a strong potential for significant losses of N and nutrient cations to soil water in hemlock stands with high mortality. These losses reduce site nutrient capital and may affect future productivity, especially on sites that were nutrient-poor prior to hemlock mortality. Nutrient losses to soil water may also lead to declines in surface water quality (i.e., increases in nutrient concentrations) in areas with significant proportions of hemlock and where hemlock is typically dominant in

> ravines and on steep slopes. Such effects on surface water quality will be particularly important to those managing forested watersheds that provide a domestic water supply. (Yorks, et al., 2000)

3. As is true with any overstory removal of trees, the loss of hemlock due either to salvage logging or defoliation and mortality results in an increase in soil moisture and subsurface flow, which also increase the likelihood of transporting both organic and inorganic nutrients to streams.

> Stand productivity and water use appear little impacted until an intermediate threshold of damage has occurred. Enhanced soil moisture availability may first be noticed toward the end of the growing season. Once trees reach heavily damaged status, water uptake and transpiration are severely reduced throughout the growing season, leaving substantially more water available for evaporation, runoff, and/or use by other plant species. (Kimple and Schuster, 2002)

4. There remains some uncertainty about the fate of individual hemlock stands. While trees eventually succumb once infected, the distribution of infection has been moderated at least by the variability in distribution vectors. Selected stands within large forests that have escaped infestation and remain healthy may be worth protecting, even at high cost. The possibility that they can persist beyond the infestation and provide landscape points from which hemlock might eventually recover, especially if natural and introduced controls eventually strengthen, should be considered (Orwig and Kittredge, 2005; U.S.D.A. Forest Service, 2005)

5. Scientists throughout the range of *Tsuga canadensis* are working to find and release safe predators shown to be effective in controlling HWA, including a wide variety of predatory coccinelid beetles and fungi. To date, these efforts have not produced controls able to keep pace with the reproduction and spread of HWA. However, our experiences with *Lymantria dispar* (gypsy moth) and the dramatic reduction of its threat brought on by the growth of *Entomophaga maimaiga*, a population-controlling fungus, raise a glimmer of hope that science and natural systems might combine to moderate the demise of the hemlock population throughout its range.

> Management of forest pests such as HWA in natural areas relies on natural controls that are simple to use and of low cost. To date the major emphasis of research in this area has been on the rearing and release of exotic coccinelid predators. However, rarely will one biological control organism—a "silver bullet"—effectively suppress serious exotic pest populations below damaging levels. More realistic is a multifaceted approach using several compatible agents that together reduce pest populations. Entomopathogenic fungi comprise a group of naturally occurring organisms that penetrate, multiply within, and ultimately kill their insect hosts. These represent a group of promising, but as yet underutilized biological control agents for management of HWA and other exotic insect pests. Fungi are particularly promising for HWA management for several reasons. They have been found infecting HWA naturally in the eastern United States and in low-level adelgid populations in China. Many species of these fungi are relatively easy and inexpensive to mass-produce, and most have little or no negative impact on the environment, humans, or non-target organisms. Production is species and strain specific, and under ideal conditions, enough material for 1ha can be prepared for under $20.00 (Wraight et al., 2001). Naturally occurring epizootics caused by fungi have been

observed in populations of scales and various aphids demonstrating the potential for their use. An additional benefit of entomopathogenic fungi is their potential to persist in an infected population, providing an ongoing chronic fungal infection. Such conditions may cause an overall reduction in health and fecundity of the pest species. This stress may sufficiently reduce the pest population to a more manageable level—a level perhaps that coccinelid predators could reduce even further. (Reid, et al., 2002)

5.2.5.1.2 DWSP Policy for Hemlock Management in Response to HWA

It is DWSP's primary objective to make forest management choices that conservatively protect the drinking water supply. Secondary objectives include the protection of biological diversity and meeting the market demand for renewable resources, in part to offset the costs of protecting the water supply. The policy outlined below factors in background information as well as these objectives, in attempting to conservatively address the hemlock woolly adelgid problem.

1. Because of the uncertainty associated with hemlock mortality and the possibility of natural or introduced biological controls, DWSP will not conduct pre-emptive harvests of hemlock. Forest stands containing greater than 50% stocking of hemlock will be monitored for the presence of HWA. When the majority (>50%) of the hemlock trees in an operable stand are infected with HWA, the stand will be considered to be infested and will be considered for a harvest/salvage operation. Exceptions include operable, infested stands within areas such as the Pottapaug Natural Area on the Quabbin Reservoir, where harvesting is generally excluded unless managers determine that it is needed to prevent the spread of an insect or disease to other parts of the watershed.

2. Due to water quality protection concerns and the likelihood of increased inorganic nutrient availability, the hemlock management policy in uplands will differ from management in wetlands and riparian zones.

In upland areas, DWSP will harvest operable, infested hemlock stands to salvage wood and to reduce potential fire and recreational hazards associated with large volumes of standing and falling dead wood, while working to meet management goals for diverse forest structure. Where possible, scattered healthy overstory hemlock trees will be retained. These salvage operations will be designed to provide enough light to stimulate a diversity of shade intolerant species to compete with the common black birch regeneration response. Enrichment planting may be used in these upland areas to strengthen the diversity of the regeneration response.

DWSP will not cut infested hemlock stands located in seasonally flooded wetlands, and will avoid running equipment in hemlock stands growing on hydric soils, except when these soils are dry or frozen enough to carry logging equipment without damage. In riparian areas, cutting practices regulations limit cutting to 50% of the basal area, thus limiting the opportunity to stimulate shade intolerant regeneration except by increasing cutting adjacent to the filter strip. Harvesting stimulates mineralization and nitrification, leading to higher inorganic N pools. Black birch is competitively enhanced by high N levels and moderate light levels. Therefore, partial harvesting in riparian areas may favor black birch rather than diverse regeneration, the opposite of the desired effects. The Division has experimented with planting in conjunction with partial cutting in riparian zones, and is working to document examples in which these trees have successfully competed with natural black birch regeneration. Riparian areas will eventually lose their hemlock to HWA, but leaving them to gradually die may reduce the risk of nutrient transport to adjacent streams, although this has not yet been adequately documented. In light of all the above, DWSP will not cut within the variable width filter strip defined by Chapter 132 regulations during salvage

operations in hemlock stands infested with HWA, unless hemlock occupies less than 30% of this filter strip, in which case up to 20% of the filter strip stocking may be cut from the non-hemlock species, to add structural diversity. This policy will be in effect until evidence from stream and soil water sampling and/or regeneration research recommends modifications.

In summary, DWSP policy regarding management of hemlock includes:

1. Monitoring of stands with greater than 50% stocking in hemlock for presence of HWA.
2. Conducting salvage cuts only in infested stands, defined as stands in which the majority of the hemlock trees are infected.*
3. Designing salvage cuts to stimulate regeneration of both shade tolerant and shade intolerant species, while retaining scattered healthy hemlock individuals, and attempting to leave sufficient stocking of other species to meet forest structural goals.
4. Leaving the variable-width filter strip (as defined in Chapter 132) uncut in hemlock salvage operations, except when hemlock occupies less than 30% of that filter strip, in which case up to 20% of the filter strip stocking may be cut from the non-hemlock species.
5. Avoiding hemlock salvage in seasonally flooded wetlands and keeping equipment off of hydric soils in hemlock stands except when they are dry enough or frozen enough to support logging equipment.

5.2.5.2 Other Insect or Disease Threats

There are many insects and diseases present in the Quabbin watershed forests, but most of these are well-controlled, endemic features of the local ecosystem and do not present significant, landscape level threats. Examples include such insects as the eastern tent caterpillar and fall webworm, hemlock looper, oak leaf skeletonizer, and diseases such as the target canker (*Nectria*) in black birch. Some pests have been brought into the system from the outside and either have already had a major impact (chestnut blight; Dutch elm disease) or have been around long enough that the system has developed controls that appear to be limiting further disastrous impacts (gypsy moth). Still others are in the middle of a gradual but ultimately devastating impact on certain species (beech bark disease, ash yellows). Finally, some long-present pest problems that have been brought under control in the past are threatening revival, e.g., white pine blister rust.

There are also threatening insects and diseases that have not yet been identified on the watershed but that have some potential to cause significant damage if they become established. The following are examples, with brief notes on their preferred hosts, biology, and potential impacts are listed below:

- Sudden oak death is a fungal disease that has killed oaks and a variety of other trees in California in as little as 2-4 weeks following infection (thus "sudden death"). So far, this disease is a problem in the western U.S., but there are concerns that it could travel via cross-continental nursery trade. With demonstrated susceptibility to this disease, the red oaks that dominate large areas of the Quabbin forest would likely be severely impacted if this disease arrives on the watershed.

- Asian long-horned beetle is a large insect (0.75-1.5 inches long) with long black and white banded antennae. It was introduced in New York City in 1996 via overseas packaging materials and has also been discovered in Chicago, New Jersey, and Toronto, among others. Millions of dollars have been spent trying to locate and destroy all infected trees in order to contain and

* Because these are salvage operations that require more rapid response than typical silvicultural operations, the DWSP internal lot review process will be conducted within four weeks of the identification of a stand as sufficiently infested to warrant a salvage cut. This determination will be made by field consultation between Forestry and Natural Resources Staff using methods mutually agreed upon to determine the condition of the stand.

eventually eradicate this insect from the U.S. If it escapes these efforts, it is potentially devastating to maples and birches.

- Winter moth has recently reached outbreak levels in coastal areas of Massachusetts. While it has not yet moved westward, it is potentially a serious problem. In Nova Scotia, it has been responsible for mortality of 40% of oak stands and is known to feed on oaks, maples, basswood, ash, and apples (www.umassgreeninfo.org/fact_sheets/defoliators/winter_moth.pdf). Control efforts on the east and west coasts of the US and Canada have included both biological controls and insecticidal chemicals.

- Sirex woodwasp was only recently discovered (2004) in New York state, the first discovery in North America of this insect, which is on the top ten list of worst forest pests around the globe. Most pines, including Eastern white pine, are susceptible, and there are no known native natural controls for this insect. New York State has recently launched a comprehensive program to try to limit the spread of this insect.

5.2.5.3 Invasive Plants

See Section 5.5.6 for a complete review and discussion on invasive plants.

5.2.5.4 Salvage Policy

Some disturbances that move through the Quabbin forest can damage standing trees in ways that result in a rapid decay in their merchantable value, sometimes in combination with an increase in fire danger, hazards to users of the forest, or blockage of access roads. Strong winds and heavy snow or ice can break or fell trees in haphazard patterns that create access dangers. Insect defoliations can kill trees rapidly and create short-term fire hazards as well as access danger. Some species lose value rapidly, for instance when white pine is felled or killed by wind during warm seasons, when the blue-stain fungus can infect the wood rapidly, significantly dropping its merchantable value.

It is Division policy that salvage cutting will only take place in forest areas that have lost (or are likely to lose in a short time period) 50% or more of their stocking, due to storms (ice, snow, or wind), fires, insects, or pathogens. Salvage sales will not go through the normal annual internal review process, but will be subject to approval by the Regional Director, the Natural Resources Section Director, and the Chief Forester before cutting can start. Salvage sales will only take place on an emergency basis when there will be significant loss of wood product value or marketability by waiting to sell these products at the next scheduled timber showing, or when access issues caused by damaged or fallen trees need immediate resolution.

5.2.6 Conservation Management Practices (CMPs) for Watershed Forest Management

NOTE: DWSP utilizes the Canadian term "Conservation Management Practices" instead of "Best Management Practices." Both terms refer to efforts to create resource-protecting standards for management activities.

Forest management at Quabbin is done to improve watershed protection. As a minimum Conservation Management Practice, DWSP will uphold the standard that no measurable negative impact will occur on the quality of water, as measured at locations downstream from a logging project. DWSP staff will measure water quality periodically upstream and downstream from logging projects to assure compliance with this standard. Described below are the specific practices designed to accomplish this compliance. It should be noted that the DWSP meets or exceeds the requirements of both the Forest Cutting Practices

Act and the Wetlands Protection Act (MGL ch. 132 and 131). Whenever these regulations are revised, DWSP management practices will meet or exceed the revised standards.

Strict adherence to DWSP's Conservation Management Practices (CMPs) ensures that forest management is conducted in a manner that does not impair water resources or other natural/cultural resources on the watersheds. Silvicultural practices, as described in the management plan, are employed to bring about specific forest conditions. These practices require the cutting and removal of overstory trees to diversify structural and species compositions and to maintain the vigor of the residual overstory. The forest is treated, on an average, every 20-30 years and at that time, 1/3 or more of a stand may be removed to establish and release forest regeneration. The process of removing trees can impact the forest and soils essential to protecting water quality if not carefully regulated.

Among the areas of greatest concern is the placement of forwarder and skid roads and log landings, where logging work is concentrated. Proper location of these in relation to streams, rivers, reservoirs, ponds, vernal pools, and bordering vegetated wetlands is important so that soils do not move from these areas into water or wetland resources. Beyond this principal concern, Conservation Management Practices are designed to diminish the negative impact of silvicultural operations on the residual vegetation, to minimize soil compaction during these operations, and to keep potential pollutants out of the water resource.

5.2.6.1 Variables

There are many variables to consider when planning and conducting a logging operation, including equipment limitations, weather, soil depth, soil moisture, topography, silvicultural practices, vegetation, and operator workmanship. Variables such as weather, soil moisture, soil depth, topography, and existing vegetation are beyond human control. The constraints they place on logging must be factored into planning, and logging schedules and expectations adjusted accordingly. Variables such as equipment, silvicultural planning, and operator workmanship can be modified, for instance, by matching allowable logging equipment with the constraints of a given site.

5.2.6.2 Logging Equipment

Logging equipment has changed dramatically in the 40 years that forest management has been active on DWSP watersheds. The primary logging machine was once the 50-70 horsepower (hp) crawler tractor-sled combination. These tracked machines were 5-6' wide and weighed 5-7 tons. Today, most logging is done with 4-wheel drive articulated skidders or 4-8 wheel drive articulated forwarders with 70-260 hp, widths of 7-10', and weights of 6-24 tons (empty) or more. Skidders drag logs attached to a rear-mounted cable and winch or a grapple, while forwarders carry logs on integrated log bunks.

Other types of logging equipment include grapple skidders, wheeled and tracked feller-bunchers, and feller-processors. A grapple is an add-on feature that replaces the winch and cable with hydraulically operated grapple arms. Feller-bunchers cut trees and put them in piles, usually for removal by a grapple skidder. There are 3- or 4-wheel feller-bunchers that must drive up to each tree for felling, whereas tracked models can fell a tree 10-20 feet from the machine. A feller-processor fells, de-limbs, and cuts trees, leaving piles of logs or cordwood, which are retrieved by forwarders. Machines that process felled trees into logs, pulpwood, or firewood are generically referred to as "cut-to-length", or C.T.L., machines.

Small skidders are useful for logging on watersheds whereas larger 100-230 hp models, that weigh from 8-18 tons and are 8-10' wide, are usually too large and heavy for stand and soil conditions. Combinations of small, maneuverable feller-bunchers and forwarders, small skidders and forwarders, and small tracked or rubber-tired feller-processors and forwarders have all worked successfully on DWSP watersheds. **Table 45** shows typical combinations of equipment that work on various types of harvesting operations on DWSP watersheds.

Table 45: Harvesting Methods/Equipment Used on DWSP Watershed Lands

Method/Equipment	4-8' Cordwood or pulpwood	8-20' Sawlogs, fuelwood, pulpwood	Whole-tree
1. Chainsaw felling with 4WD pickup truck	✓		
2. Chainsaw felling with cable skidding	✓	✓	✓
3. Chainsaw felling with forwarding	✓	✓	
4. Rubber-tired, four-wheeled feller/buncher with grapple skidding		✓	✓
5. Rubber-tired, four-wheeled feller/buncher with chainsaw limbing and forwarding		✓	
6. Rubber-tired, three-wheeled feller/buncher with grapple skidding			✓
7. Tracked feller/buncher with grapple skidding		✓	✓
8. Tracked or rubber tired CTL with forwarding	✓	✓	

In an effort to specify equipment that is appropriate on specific soils and within specific forest types, DWSP has determined ground pressure and width measurements for most of the equipment common to the area, and specifies restrictions, where needed, in timber harvesting contracts. Widths are either from direct measurement or from manufacturer's specifications; ground pressures are based upon a formula that combines machine weight and weight of an average load of logs with an estimated footprint for the tire size specified, at an average tire inflation pressure. Examples from this rating system are listed in **Table 46** (skidders) and **Table 47** (forwarders).

Rubber-tired skidder.

Forwarder with tracks

Table 46: Sample Skidder Sizes and Ground Pressures

Machine Model	Tire Size (inches)	Width (inches)	Ground Pressure (lbs/sq in.)
Cable skidders			
TimberJack 208	23.1 x 26	102	4.9
JohnDeere 440C	23.1 x 26	102	5.0
Franklin 105XL	23.1 x 26	110	5.3
TreeFarmer C4	18.4 x 26	93	6.5
JohnDeere 540	23.1 x 26	105	6.6
CAT 508GR	23.1 x 26	106	7.1
Clark 665	23.1 x 26	114	7.9
Clark 665	18.4 x 24	104	9.5
TreeFarmer C6	18.4 x 34	97	10.1
CAT 518	18.4 x 34	99	11.2
Grapple skidders			
Franklin Q80	30.5 x 32	131	7.9
Prentice 490	24.5 x 32	118	10.0
Tigercat 610	24.5 x 32	115	9.7
John Deere 648G	24.5 x 32	123	8.2
Caterpillar 525C	30.5 x 32	133	8.2

(Sources: Firestone Tire Co. – LS-2, Forestry Dimension Special Table)

Table 47: Sample Forwarder Sizes and Ground Pressures

4 Axle Forwarders	Tire size (mms x inches)	Width (inches)	Ground pressure (lbs / sq. inch) *Unloaded*	*Loaded*	*Loaded, with Eco Tracks*
Rottne/Solid F12	700 x 26.5	112	5.6	10.1	6.8
John Deere 1110	600 x 26.6	107	5.3	14.5	12.4
Timberpro 815	700 x 26.5	113	3.4	14.5	10.3
Valmet 860	600 x 22.5	110	5.5	17.4	9.9
Caterpillar 574	700 x 26.5	111	5.6	15.7	9.3

(Sources: Caterpillar Inc, Forest Products Forwarders Ground Pressure Table: Forestry Research Institute of Sweden (Skogforsk) & Forest Engineering Research Institute of Canada (FERIC)

Some of the logging equipment available is too large or heavy to meet DWSP requirements in certain vegetation or soil conditions; some is limited by terrain. Matching the equipment with the site conditions so that minimal damage occurs is critical to the success of watershed silvicultural activities. DWSP specifies equipment requirements for each site in its harvest bidding. This includes machine width and ground pressure limits, as well as specific equipment requirements. While each site has unique conditions

that require the experienced judgment of the forester to predict impacts, ground pressures are generally limited to 8 pounds per square inch or less on soils that are less well-drained. Machine widths are limited in intermediate cuttings of dense, unthinned stands with moderate topography, most typically to around 8.5 feet.

An example of a "preferred logging system," that accomplishes DWSP goals under difficult conditions is a small C.T.L. processor and forwarder combination, used for thinning dense pine plantations on a variety of soil conditions. Both machines are able to work in these conditions with minimal root, stem, crown, or soil damage. In addition, these machines can successfully work around walls and foundations and do not require a landing, as logs are stacked on the roadside. This combination can also work in previously thinned stands that have an understory of young trees, with minimal damage to the young growth. Generally, when trying to save and promote growth of advance regeneration, fixed head processors are required. Dangle heads are allowed when damage to advance regeneration is not a concern, due to its scarcity or poor condition.

Rubber-tired C.T.L. machine with a dangle head processor

While smaller tracked feller-processors are limited to stable ground conditions (few rocks and gentle slopes) and trees less than 16" DBH, current models can fell trees up to 30" DBH and come equipped with self-leveling cabs that allow work on slopes up to 30% and rubber tires that allow work on rocky ground. In old stands where the trees are generally large, hand felling is necessary. Multi-aged stands will always have many more stems/acre than the present even-aged stands and consequently are more difficult to work in without damaging residual trees. A combination of a winching machine and forwarder works well in multi-aged stands. This logging system addresses the problem of damage to the residual trees associated with long skid roads.

Table 48 summarizes some of DWSP's effort to match equipment and logging systems with site conditions. The methods listed in **Table 49** are taken from **Table 46**.

Table 48: Harvesting Methods/Equipment Used in Various Soil/Terrain Combinations

Slope	Excessively drained soils	Well-drained thin soils	Well-drained thick soils	Moderately well-drained soils	Poorly to very poorly drained soils
Level to 10% grade	Methods 1-8	Methods 1-8	Methods 1-8	Methods 1-8 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	Generally not worked with machines
11-20% grades	Methods 2-6	Methods 2-6	Methods 2-6	Methods 2-6 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	NA
Slopes greater than 20%	Method 2	Method 2	Method 2	NA	NA

5.2.6.3 Silvicultural Planning

Silvicultural plans have to address present and future cutting practices, landscape aesthetics, cultural resources, wildlife resources, wetlands, and rare or endangered species. While the protection of non-tree resources is of particular concern, the most difficult aspect of planning concerns the maintenance of multi-age stands of trees. These stands have great numbers of trees, especially seedlings, saplings, and poles that are more easily damaged than larger trees. The positioning of permanent logging roads, landings, and small and large group cuts is crucial to the long-term success of silviculture. Logging operation success and optimal protection of water resources are dependent upon careful advance planning (see **Figure 17** for an example of silvicultural planning). For example, the best possible stream crossing is the one that is avoided by planning.

A well-planned harvest

5.2.6.4 Operator Workmanship

Operator workmanship is one of the most crucial and variable factors in forestry operations because good planning and preparation can be negated if operators perform poorly. Most loggers are paid on a piecework basis. Their paycheck does not always relate to how hard or how carefully they worked, but on the amount of wood that gets to the mill. DWSP, however, maintains tight control over loggers working on the watersheds and exercises its right to remove operators who fail to adhere to contract standards. Furthermore, every harvesting operation receives a written post-harvest inspection and evaluation report that is filed for future determination of the operator's commitment to good workmanship. It is important that foresters and loggers develop mutual respect that is based upon a shared commitment to the sustainable stewardship of the land over long periods of time.

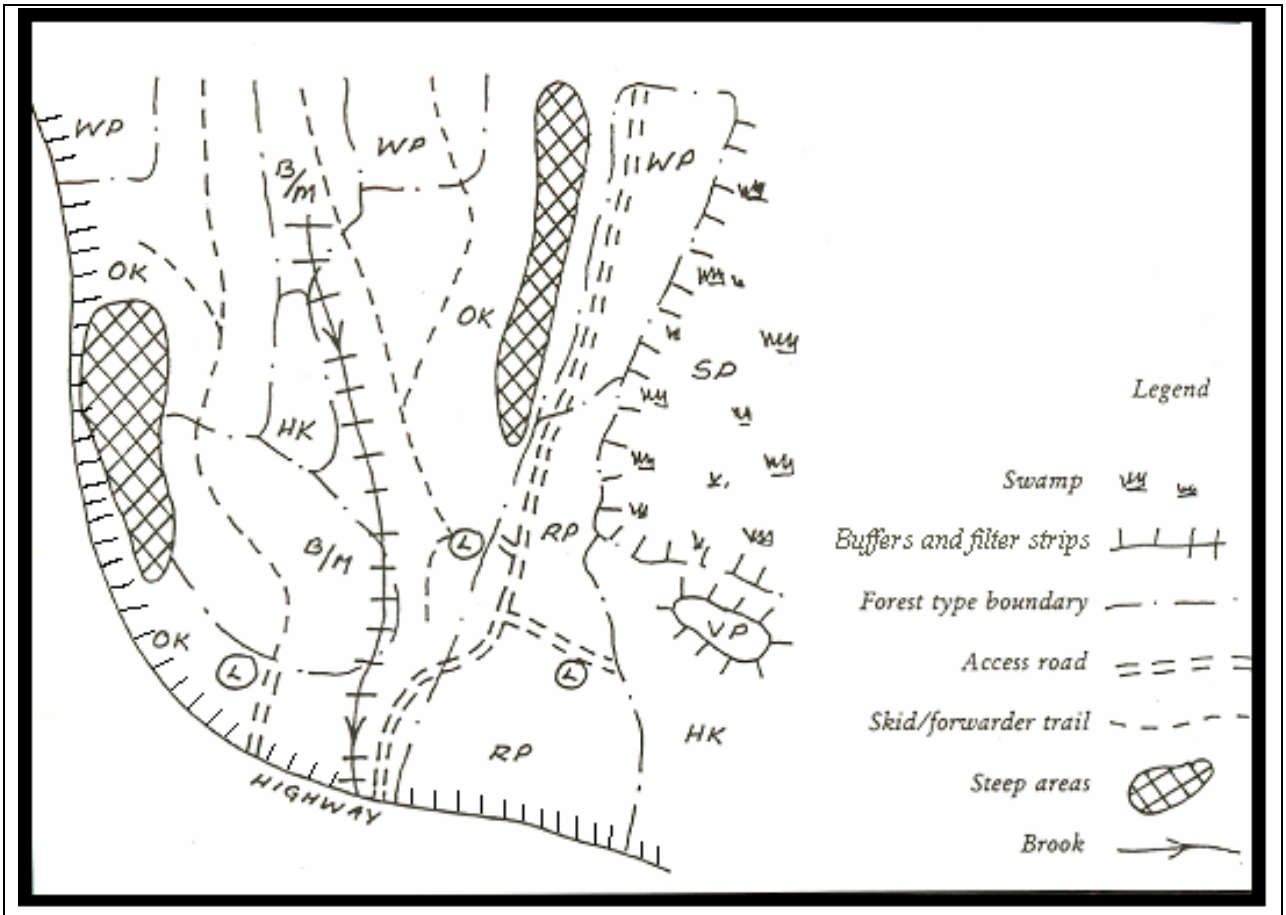
5.2.6.5 Filter Strips

Filter strips are vegetated borders along streams, rivers, or water bodies (including vernal pools) and represent the final opportunity to prevent transport of sediment or nutrients into streams or reservoirs from nearby roads or landings. When roads and landings are near water resources, filter strips are given special attention. Chapter 132 (Forest Cutting Practices regulations) requires a 50 foot filter strip, in which cutting is limited to 50% of the basal area and machinery is generally not allowed (exceptions include stream crossings). Chapter 132 regulations require increasing the filter strip based on slope conditions and along Outstanding Resource Waters (protected public water supplies) and their tributaries (excluding vernal pools and bordering vegetated wetlands), streams that are 25 feet or more from bank to bank, ponds of 10 acres or greater, and designated scenic rivers. DWSP meets these requirements and also increases the filter strip, based on both slopes and soils, for other areas not included in the definitions above. For example, on moderately and poorly drained soils the filter strip is increased 40 feet for each 10% increment of slope angle above 10%. On well-drained outwash and till soils the filter strip is increased 40 feet for each 10% increase in slope angle above 20%. Equipment may enter the filter strip in limited cases where streams must be crossed.

5.2.6.6 Buffer Strips

Buffer strips are retained and managed for aesthetic purposes along the edges of highways and public roads. Chapter 132 requires that within this strip, no more than 50% of the basal area can be cut at any one time and that no additional trees can be cut for five years. Buffer strips will be 50 feet except along designated scenic roads, where Chapter 132 requires them to be 100 feet in width.

Figure 17: Hypothetical Example of Silvicultural Planning



This approximately 200 acre area of DWSP forest contains separate stands of white pine (WP), hemlock (HK), birch/maple (B/M), oak (OK), spruce (SP), and planted red pine (RP). A fire in 1957 severely burned the lower 1/3 of the area, and the red pine was planted shortly after this fire. The topography and hydrography of the area include large areas of well-drained sandy soils, but also several small steep areas, a year-round brook, a swamp, and a vernal pool (VP). These areas are delineated with buffers where required. Work within these areas is restricted; steep areas and muck soils are not worked, and filter strips are only worked on frozen or dry ground. Fairy shrimp and mole salamander eggs have been found in the vernal pool, verifying its importance to wildlife. No work is proposed adjacent to this pool.

Except for the steep and wet areas, all the stands have received improvement thinnings within the past 30 years, and the understory has developed in response to deer control. Additional work in this area will release advance regeneration and/or establish new age classes by harvesting overstory trees in patches averaging 1 acre in size. Primary access is across the permanent road shown by a double dashed line. Single dashed lines are skidder and forwarder roads that have been used in the past and seeded and drained to prevent erosion. Landings are designated by a circled L, and represent areas used in the past and maintained as wildlife openings between operations. These roads and landings will be used again in current operations, and then returned to grass. There is evidence that the landings have been used between operations by wild turkey.

5.2.6.7 Wetlands

DWSP's forest management operations will comply with all the requirements of the Wetlands Protection Act, MGL Ch. 131 s 40, and the Forest Cutting Practices Act MGL Ch. 132 s 40-50 for cutting in wetlands (including bordering vegetated wetlands and freshwater wetlands as defined in the most current revision of Ch. 131 and 310 CMR 10.00, and as these are revised). Generally, activities that are not conducted under a Ch. 132 Forest Cutting Plan but will alter wetland resource areas or land within a 100 foot "buffer zone" beyond the water or the bordering vegetated wetland are subject to approval through the filing of a Notice of Intent with the local conservation commission.

All DWSP silvicultural activities that involve wetland resources are conducted under a Chapter 132 cutting plan, and therefore are exempt from Chapter 131 procedures, with the exception of limited amounts of work that does not include harvesting, including planting, pruning, and pre-commercial thinning and maintenance of boundaries and fire breaks. All of these latter activities are defined as "normal maintenance of land in agricultural use" by Chapter 131, and are therefore exempt from its filing procedures.

Chapter 132 requires a 50 foot filter strip along all water bodies and Certified Vernal Pools (see Section 5.4.3.1.1 and **Figure 18**), but allows harvesting in wetland areas provided that no more than 50% of the basal area is cut and the ground is only traveled by machinery when it will support that machinery (when it is frozen or dry). In addition, DWSP does not allow machinery within low, flat wetland forest with deep muck soils that are seasonally flooded, even though statewide regulations allow work in some of these areas during frozen or dry conditions. Most of the muck soils on DWSP lands at Quabbin are included within the designated wetlands on the watershed. DWSP has identified and mapped 3,012 acres of wetlands within the Quabbin property, which are generally avoided when lot boundaries are drawn for proposed annual silvicultural operations. DWSP also adheres to the statewide recommended practices for protection of vernal pools, including a 50 foot shade zone and a 200 foot buffer (see **Figure 18**).

Figure 18: Timber Harvesting Guidelines near Vernal Pools.

Adapted from guidelines that were cooperatively developed by foresters and wildlife biologists in Massachusetts.

Vernal pools provide critical habitat for a number of amphibians and invertebrates, some of which breed only in these unique ecosystems, and/or may be rare, threatened or endangered species. Although vernal pools may only hold water for a period in the spring, the most important protective measure is learning to recognize these pool locations, even in the dry season. Foresters can then incorporate the guidelines below in their plans to ensure that these habitats thrive.

Vernal Pool and Depression — *No activity*

Objective 1: Maintain the physical integrity of the pool depression and its ability to hold seasonal water.

1. Keep heavy equipment out of the pool depression at all times of the year. Rutting here could cause the water to drain too early, stranding amphibian eggs before they hatch. Compaction could alter water flow and harm eggs and/or larvae buried in leaf litter at the bottom of the depression.
2. Prevent sedimentation from nearby areas of disturbed soil, so as not to disrupt the pool's breeding environment.
3. Keep tops and slash out of the pool depression. Although amphibians often use twigs up to an inch in diameter to attach their eggs, branches should not be added, nor existing branches removed. If an occasional top lands in the pool depression leave it only if it falls in during the breeding season and its removal would disturb newly laid eggs or hatched salamanders.

Shade Zone — *100 foot buffer around pool edge*

Objective 2: Keep a shaded condition in this 50-ft. wide buffer around the pool depression. Amphibians require that the temperature and relativity humidity at the soil surface be cool and moist.

1. Light, partial cuts that can maintain this microclimate are acceptable; clear cuts are not.
2. Understory vegetation such as mountain laurel, hemlock, advance regeneration or vigorous hardwood sprouts after a harvest will help to maintain this condition. Avoid leaving only trees with small or damaged tops, or dead and dying trees.

Objective 3: Minimize disturbance of the forest floor.

1. Operate in this area when the ground is frozen and covered with snow, whenever possible. When operations must be scheduled in dry seasons, keep equipment 50 feet away from the pool depression and winch out logs.
2. Avoid operating during muddy conditions that would create ruts deeper than 6 inches. Ruts can be an impediment to migrating salamanders, some of which are known to use the same vernal pools and migratory routes for 15 to 20 years.

3. Minimize disturbance of the leaf litter and mineral soil that insulate the ground and create proper moisture and temperature conditions for amphibian migrations.

Low Ground Disturbance Zone *50-200 feet from pool edge*

Objective 4: As above, minimize disturbance of the forest floor in this area.

1. Operate equipment in this area when the ground is frozen or covered with snow, whenever possible.
2. Follow 2 and 3 from objective 3 above.
3. Locate landings and heavily used skid roads outside of this area. Be sure any water diversion structures associated with skid trails and roads do not connect to or cause sedimentation in the shaded zone or the vernal pool itself.

5.2.6.8 Logging Practices

A primary purpose of CMPs is to prevent or minimize the movement of soil to the water resource. During a logging operation, this is most likely to occur on a landing or skid/forwarder road. In these areas, the humus layer is sometimes lost and the soils may be temporarily compacted and channelized so that water will flow over the surface instead of passing through the soil. If the road is unwisely placed on a continuous slope, rainwater will increase in volume and velocity as it travels down-slope, scouring the path, removing soil, and creating a gully. If the road connects with a stream, the suspended soil may be carried much further. The result of careless logging practices can be erosion, increased stream turbidity levels, and deposition of the eroded materials downstream.

Logging practices and the human behavior necessary to avoid environmental degradation during logging are discussed in the following sub-sections. A cutting plan still relies upon the judgment and common sense of the logger and forester to make the right decisions in order to protect the land and associated resources.

5.2.6.8.1 Landings

A well-organized log landing

Landings are permanent sites that should be located on well-drained ground and soils that will support the logging equipment. Frozen soils are desirable because they support heavy trucks, but these conditions cannot be assumed to occur for more than a month or two each year. When located on moderately drained soils, landings are constructed with natural and/or man-made materials that prevent rutting and maintain a workable surface. This generally includes the use of crushed gravel, which allows water infiltration and supports heavy equipment, and may also include the use of "geo-textiles," woven road construction fabrics that prevent mixing of gravel with the soils below. Landings will not be accessed by skidder or forwarder roads that direct water into the landing. An effective barrier is maintained between the landing and access road (road ditch, hay bales, etc.) and landings are required to be smoothed and seeded after use.

5.2.6.8.2 Skid Roads

Skid roads are designed to be re-used and are therefore located on soils that can support the skidder, such as well-drained gravel or well-to-moderately-drained stony till soils. Some soils, regardless of their drainage capacity, are wet in the spring, early summer and late fall; harvesting must be scheduled for dry or frozen conditions. Skid roads are cut out before use and limbs left in the road to protect the soil. Skid roads are relatively straight to avoid damaging roadside tree stems and roots, but they are not allowed to carry water for more than 100 feet. Continuous grades are deliberately interrupted to divert rainwater off the road. Most skid road grades are less than 10%, but in some cases, climbing grades may reach a maximum of 20%. These steeper climbing grades are limited to 200 continuous feet. Downhill skidding grades are allowed up to 30% but for no more than 200 feet on grades greater than 20%. On skidding grades greater than 20%, which are not protected by frozen ground or snow cover, tree branches will be put on the road and other erosion-control measures taken as necessary.

Skidding distances are minimized to prevent excessive wear to roads unless frozen ground, snow, or rocks protect them. Skidder width and weight requirements are tailored to site conditions. The Division has rated many commercially available skidders by taking into account their horse power, weight, load capacity, tire size, and width to determine their suitability for logging on water supply watersheds (see Table 48 for examples). Skidder width ranges from 85-114 inches and loaded ground pressures range from 5-11 lbs/sq inch. Typically, machines with loaded ground pressures of 8 lbs/sq inch or less and widths of 102" or less are allowed on sensitive Division watershed lands. Skidding is stopped when rains or thaws make the soils unable to support skidders.

At the end of the logging operation or when work is suspended, skid roads are stabilized to prevent erosion. This task is accomplished through the construction of water bars. On slopes greater than 10%, water bars are spaced every 50 feet and on slopes less than 10%, they are spaced every 100 feet. It is sometimes difficult to regularly space water bars due to rocky conditions and lack of places to discharge water, so spacing may vary. Water bars are designed to meet two criteria:

- They must angle across and down the road to create a 3-5% pitch.
- They must discharge water to an area that drains away from the road.

A skidder can usually be used to construct water bars unless the soils are very rocky or ledgy. In rocky soils, they may have to be dug by hand. They do not have to be more than 6-8 inches deep, including the berm, unless they have to deflect more than the overland flow off skid roads (in which case depths are doubled). After completion of logging, water bars on skid roads are seeded during the growing season.

5.2.6.8.3 Forwarder Roads

Forwarder roads are located on soils that can support these machines. The layout of forwarder roads is more flexible than for skid roads because forwarders do not require straight roads. Forwarder roads can pass through the forest avoiding soft soils, trees, and sloping ground. Forwarder roads usually have less than a 5% slope with an occasional grade up to 10% for a maximum of 100 feet. Forwarder roads sometimes require rough preliminary grading to remove stumps and rocks. Forwarders were originally designed to stay on the road and pick up logs brought to the road by a skidder, but they also replace skidders when soil and/or vegetation conditions and cultural features cannot accommodate skid roads and skidder landings. In operations that combine skidders and forwarders, skidders operate the sloping and rough ground for distances of less than 1,000 feet, while forwarders operate on the more level terrain and handle long hauling distances. Water bar requirements for forwarder roads are the same as for skid roads.

5.2.6.8.4 Stream Crossings

Stream crossings are usually avoidable on DWSP watershed properties. Frozen conditions are favored whenever possible when streams must be crossed. These conditions not only protect the actual crossing, but also protect the approach and limit the amount of soil carried in machine tires or on skidded logs.

Skidder on a temporary bridge

Portable bridging is used to cross all streams with a continuous flow. This bridging consists of either pre-fabricated sections transported to the site (the Division has constructed portable bridge sections for use by private contractors), or site-constructed bridging. Past studies (Thompson and Kyker-Snowman 1989) have shown that machine placement and removal of crossing mitigation can move substantial sediments into the stream, especially where banks are steep or unstable. Therefore, it may be preferable in some conditions to construct mitigation on-site and without machinery. In either case, the bridging will be designed and constructed so as to prevent degradation of stream water measured downstream of the logging activity before, during, and after that activity.

Correct location of crossings is important in order to avoid soft soils that the machine may carry onto the bridge and into the water. Chapter 132 requires that all crossings be marked with paint or flagging and carefully mapped prior to filing of a cutting plan. All crossings are made at right angles to the streamflow. If frozen conditions are not available, then banks and adjacent soils are protected with tops of trees, poles, or other suitable material. In all crossings, any mitigation that involves structures that obstruct streamflow is designed and installed to accommodate the 25-year stormflow for the upgrade drainage. All temporary crossing construction is removed at the completion of the operation, and the site stabilized. Division foresters supervise the design, construction, placement, and removal of bridging or other mitigation and the proper protection of approaches, prior to the commencement of logging on the site.

Crossings of small, intermittent streams subject to MGL Ch. 131/132 protection (those portions downstream from the highest bog, swamp, wet meadow, or marsh in the drainage) are mitigated to prevent measurable downstream water quality degradation when these streams are flowing. These streams are only crossed without mitigation during frozen or dry conditions (when they are not flowing). No intermittent stream crossing will be allowed that would result in rutting or disruption of stream bank integrity. Chapter 132 further requires that all streams within 1,000 feet of the reservoir high water mark, including intermittent streams downstream of the highest wetland, must be crossed with portable bridging. Division foresters will frequently monitor all unbridged crossings, and discontinue or mitigate them if conditions deteriorate or downstream water quality is threatened.

DWSP crosses streams on a very limited basis. For example, from 1978 to 1990, the Division conducted 130 logging operations on the Quabbin and Ware River watersheds that involved 12 stream crossings (7 were across existing culverts, two were mitigated with DEM-approved techniques and three were crossings of intermittent streams in dry or frozen conditions).

Table 49 outlines the various stream-crossing situations encountered on DWSP watersheds and level of protection these crossings are given.

Table 49: Protection Measures Applied to Various Stream Crossing Situations

Type of Crossing Situation	Level of Protection		
	CMPs Only	Mitigate	Bridge
Intermittent stream, above the highest wetland in the drainage.	✓		
Intermittent stream, downstream of highest wetland, when not flowing; crossing further than 1,000 feet from reservoir high water mark.	✓		
Intermittent stream, downstream of highest wetland; crossing further than 1,000 feet from reservoir high water mark; when flowing.		✓	
Any intermittent stream with unstable banks/approach; regardless of flow conditions.		✓	
Intermittent stream, downstream of highest wetland, crossing within 1,000 feet of reservoir high water mark; regardless of flow conditions.			✓
Continuously flowing stream.			✓

"Wetland" refers to bogs, swamps, wet meadows, and marshes.
"Mitigate" includes use of poles, brush, or slabs placed in or beside a small stream to minimize equipment impacts on bank or streambed integrity.
"Bridge" includes installed or site-built structures that are above the stream profile and capable of keeping all equipment and harvested products out of the profile.

5.2.6.9 Point-Source Pollution Control

This section describes methods for control of petroleum product spills, human waste, and the disposal of rubbish generated by loggers and logging machinery maintenance. In addition, see Section 5.3.6.4, Pre-Planned Spill Response for Silvicultural Operations. The following are definitions used within this Section.

- Petroleum products: All machines are inspected by DWSP foresters for leaks prior to arrival and for the duration of their stay on the watershed. Checks are made of all hydraulic components, fuel tanks and lines, engine, transmission and axles. Trucks, forwarders, skidders and other equipment that carry petroleum products must have a sufficient number of petroleum-absorbent pads to contain a 10-gallon spill per machine on site. Immediate action to contain and stop any petroleum spills followed by prompt notification of the forester is required. The forester in turn contacts DWSP Environmental Quality personnel.

  All petroleum products that are not in machine storage are stored in safe durable containers and removed from the watershed at the completion of each day. Petroleum storage is only allowed in tanks designed, manufactured, inspected, and certified for commercial use. No re-fueling or servicing is allowed within the 50 foot filter strip along water bodies or within 25 feet of any wetland.

- Human waste: Deposition of human solid waste is not allowed on the watershed. Contract specifications require the use of a portable bathroom facility (a minimum of a "Coleman" type of

chemical toilet). The only exception to this policy will be the use of existing sanitary facilities on the watershed, which include those installed for recreational access.

- Rubbish: All waste material, including parts, packaging, lubricants, garbage, sandwich wrappers, and other litter must be stored in appropriate containers and removed daily from the watershed.

5.2.6.10 Fire Prevention

Fire prevention concerns both the forest and machinery. MGL Ch. 48, s. 16, a.k.a. the "Slash Law," adequately deals with the disposal of slash along boundaries, water bodies, wetlands, highways, roads and utility right-of-ways. Slash is not allowed within 25' of any stream, river, pond or reservoir. This law is also the DWSP standard.

Machine fires can spread to forest fires and cause water and soil pollution. Keeping a leak-free, well-maintained machine and having the proper fire extinguishers on the machine can prevent damaging machine fires. All machines are inspected for proper fire extinguisher and spark arresters by a DWSP forester before entering the site.

5.2.6.11 Protection of Residual Vegetation

Avoiding damage to roots, stems, and crowns of understory and overstory vegetation is essential in maintaining a protection forest. Damage can occur from unskilled tree felling, skidding, forwarding and the development of skid/forwarder roads. Skilled loggers and foresters can prevent most damage by using the proper logging system. Division contracts include the right to suspend operations due to operator inexperience or negligence.

5.2.6.12 Cultural Resource Protection

The protection of cultural resources fits well with watershed management because they both require low-impact logging systems. For example, small versatile equipment can reduce soil compaction and work around walls and foundations without damage. In many locations, there are no places for a landing due to cultural sites or poor soil conditions. Forwarders mitigate this problem by stacking logs on the roadside. The "preferred logging system" in these situations is a combination of cutting, lifting, or winching trees out, and forwarding them to an appropriate landing to meet cultural resource protection objectives (see Section 5.6 for a more detailed discussion on this subject).

5.2.6.13 Aesthetics

Aesthetics can be affected by all of the practices described in the above sections, and are the demonstration of workmanship quality. The maintenance of aesthetics reflects how loggers feel about their work and the land. This perspective cannot be forced, but it can be encouraged and learned. When work is done correctly it is not conspicuous, but when done carelessly it is obvious to all. DWSP watershed land is public property; the general public regularly passes through either along public roads or on roads within the watersheds. Attention to aesthetics is important everywhere, but most important along traveled ways. All slash and debris from fallen trees is kept 20' back from the road's edge or on the backside of a bordering stone wall. Landings are cleaned of unmerchantable tree debris. Care is taken to maintain large roadside trees and to promote replacement trees.

5.2.7 Control of Harvest Operations through Timber Sale Permit

5.2.7.1 Introduction

In conducting silvicultural operations that remove forest products from the forest, DWSP policy is to protect watershed resources such as water quality, soils, residual trees, and cultural resources. Both the timber sale permit, discussed in this Section, and Conservation Management Practices, presented in Section 5.2.5, address these concerns. In general, the Permit to Harvest Forest Products specifies the performance standards, whereas the CMPs explain how these permit specifications are met.

The timber sale permit consists of written specifications, pages detailing the forest products offered for sale, maps delineating the sale area, and a proposal page where a bid for the timber is entered and signed. The written specifications deal most directly with protecting watershed resources. Specifications consist of five parts: a.) General Conditions; b.) Water Quality Specifications; c.) Harvesting Specifications; d.) Utilization Standards; e.) Silvicultural Specifications; f) Harvesting Systems; and Bidding, Payment and Bonding Specifications. Parts b, c, and f pertain most directly to protecting watershed resources.

5.2.7.2 Water Quality Specifications

Water quality specifications are primarily concerned with petroleum leaks and spills and control of human waste. Petroleum products are required to be kept in suitable containers and removed from the work site each day, unless stored in tanks designed for fuel, such as those on the logging equipment. Oil absorbent pads and blankets are required on site and with all equipment, in order to intercept and immediately control a petroleum spill, should one occur. All associated refuse from maintenance and repair is required to be stored in appropriate containers and removed from DWSP lands as soon as possible. Human waste is required to be deposited in DWSP toilets or toilets supplied by the operator.

5.2.7.3 Harvesting Specifications

Harvesting specifications are concerned primarily with the process of cutting trees and removing forest products from the forest. DWSP timber harvesting permits specify conditions for lopping slash to enhance decomposition and reduce fire hazards.. The penalty for cutting unmarked trees is set at three times the value of the tree. Utilization standards are specified in each permit in order to limit slash. There are also specifications to limit damage to residual trees and soils, especially in the felling and removal of forest products. Locations for logging roads and landings are determined by the forester; the permit specifies the condition in which these areas must be left at the completion of the operation. The permit makes it clear that the logging operation may be suspended due to wet or extremely dry conditions, at the forester's discretion.

5.2.7.4 Harvesting Systems

These specifications limit the size of skidders and other equipment to minimize soil compaction and rutting and to minimize physical damage to residual trees and cultural resources. These specifications may require specific equipment due to the conditions of the lot. For instance, where it is difficult to place straight skid trails, or where dense regeneration is present, the forester may specify that a forwarder must be used and that skidders are not allowed. Where hauling distances to a truck landing are long, but the lot itself requires skidding, the forester may require that both pieces of equipment must be used. DWSP also may require a tracked feller-buncher-processor on lots that have sensitive cultural resources requiring specialized tree removal, on soils that cannot support heavy equipment, or in stands with heavy forest stocking that cannot be thinned properly with standard equipment.

5.2.8 Internal Review of Proposed Harvesting

The key to the proper protection and management of the resources under the care and control of DWSP is the care and expertise of the staff. As the on-the ground implementers of DWSP's land management plans and policies, the foresters' knowledge of, and sensitivity to the various aspects of the watershed management plan have a direct bearing on the ultimate success of the program. It is impossible, however, for any one individual to assimilate all aspects of the diversity of knowledge in the evolving fields of natural and cultural resource management. A secondary key to implementing sensitive management, therefore, is in-house review by specialists in the various key disciplines of study in natural and cultural resources, and effective communication between these specialists and the forest managers.

Within DWSP, these supporting disciplines include wildlife biology, forest planning, water quality and environmental engineering, civil engineering, and cultural resource protection. Experts available outside DWSP include rare species botanists and zoologists (Massachusetts Natural Heritage and Endangered Species Program) and cultural resources specialists (Massachusetts Historic Commission). DWSP also has available a wide variety of experts conducting academic research on the watersheds at any given time, in part because of the research value of the resources under DWSP's care and control. These professionals and interested non-professionals who spend time studying and exploring the watersheds contribute invaluable observations that complement DWSP's understanding of its watershed resources.

To efficiently and effectively coordinate and focus this collective knowledge towards the improved protection of the drinking water supply and other natural and cultural resources, DWSP has developed the following procedure for the annual review of all proposed DWSP forest management activities on the Quabbin Reservoir watershed. These reviews are in addition to the general guidelines for cultural and wildlife resource protection.

- Each December, DWSP's foresters compile a plan of all proposed forest management that could occur during the next fiscal year (July-June). The only operations not included are emergency salvage following natural disturbance events. Each January, the foresters carefully map and describe the boundaries of each planned operation so that they are readily distinguishable on the ground (where boundaries are not easy to describe, they are marked with flagging). These outer boundaries may include internal areas where logging is restricted (vernal pools, stream filter strips, etc).

- Quabbin foresters or Natural Resources staff digitize the maps of the planned operations, which include the location of wetlands and previously identified critical cultural and wildlife sites. The foresters then submit these maps and completed forms describing the proposed silviculture in detail to the DWSP Natural Resources Section. Natural Resources staff prepare area summaries of these operations, and check the overall consistency of the operations with management plan silvicultural and resource protection objectives. These proposals will also identify the subwatersheds intersected by the proposed lots, as well as the proportion of each lot that falls within Zones 1, 2, and/or 3. Natural Resources staff will compare the proposed subwatershed and zone coverage to target objectives for the year and for the decade. After Natural Resources staff have reviewed the proposed operations, the Natural Resources Director then forwards copies to the watershed Regional Director, the DCR archaeologist, and the DWSP wildlife biologist.

- For proposed lots with openings that exceed 2 acres in size, the forester proposing the lot will also detail the relative hydrological sensitivity of the area on which these are proposed as well as the value of the larger openings as early successional habitat that benefits rare and uncommon species and as uncommon forest habitat for more common species. These lots will be reviewed internally on that basis, but prior to being approved, they will also be presented to the general public, for review and comment, at the annual spring public meeting and will also be presented for review and comment to the Quabbin Watershed Advisory Committee.

- From 1986 to 1996, a variety of consultants, in collaboration with Boston University's Department of Archaeology and the Swift River Historical Society compiled cultural resource maps for Division watershed properties (available for review through DWSP Interpretive Services at the Quabbin Visitor Center). These maps denote known and likely historic sites. When forest management is planned for areas containing or likely to contain cultural resources, the DCR archaeologist identifies types of activity that could damage these resources, such as soil compaction or disruption of existing structures such as walls or foundations. The Archaeologist may also make recommendations for removing trees that threaten existing historic structures, and identifies areas of high, moderate, or low probability of containing prehistoric occupation sites. With these concerns in hand, the foresters modify timber-harvesting approaches as needed to protect these resources.

- Each spring, DWSP's wildlife biologist reviews the planned forest management operations. Where necessary, the wildlife biologist conducts site examinations. Landscape level wildlife changes over long time spans will also be tracked using an evolving set of techniques. Local knowledge of state rare, endangered, and threatened species is referenced, as well as the location of any critical or important habitat features in the wildlife biologist's files. After completion of fieldwork by the wildlife biologist, the foresters are alerted to any potential conflicts between the proposed work and important habitat features, keyed to flagging on the ground where necessary. Specific wildlife Conservation Management Practices are outlined in Section 5.4.3 of this plan.

- Each spring, DWSP's Environmental Quality staff reviews the planned forest management and, where necessary, conducts site examinations. The Environmental Quality staff may give site-specific guidelines regarding special precautions designed to increase the protection of site water quality.

- In 1995 and 1996, the Division contracted with a professional botanist to review all proposed harvesting lots for the presence of rare or endangered plant species. The bulk of this plant inventory occurred during May and June, although the botanist made preliminary recommendations pending an additional survey for late flowering species, conducted in August, for a limited number of these operations. In the final reports, the botanist made specific conservation management recommendations to protect these plant populations.

- Where the review process identifies undesirable potential impacts, the foresters consult with the reviewers to design a practical solution. If there are any changes in the area to be harvested and/or in the proposed practices, the forester is responsible for notifying the Natural Resources Section in order to determine if further review is required by the changes. Once the review process is complete, the foresters lay out and mark the harvesting lots. At this time a Forest Cutting Practices Act (MGL Ch. 132) Cutting Plan is prepared (outlining skid roads and specific site impacts), which the logger is required to follow. The Forest Cutting Plan is submitted to the DCR Bureau of Forestry and copied to the local Conservation Commission.

- After the lot has been advertised and awarded to a private timber harvester, Chapter 132 requires DCR Bureau of Forestry staff to conduct a site visit prior to the start of the operation if wetland resources are involved. These regulations also require that DCR Service Foresters check all cutting plans against the Natural Heritage maps of rare and endangered species habitats and, if they overlap, submit these plans to Natural Heritage for review and comment. Training sessions were held in 2004 to enhance the relationship between DCR foresters and the Natural Heritage staff (which remains overburdened with review responsibilities), and an Interagency Service Agreement is being completed to enable improvements in this critical collaboration.

Throughout the active operation, it is the responsibility of the forester in charge to continuously monitor compliance with water quality protection measures, including: stream crossings and work near wetlands; conditions of skidder and forwarder roads as well as main access roads; equipment maintenance; and the treatment and placement of slash. The DWSP "Permit to Harvest Forest Products" includes detailed specifications for each harvesting operation. During the operation, DWSP reserves the right to suspend the harvesting activity if warranted by weather, soil, or wildlife conditions. Upon completion of silvicultural operations, it is the responsibility of the foresters to check for full compliance with all timber harvest permit specifications prior to the release of the performance bond and filing of final reports.

A separate review process is required for proposed access road development or the opening of new gravel operations. See Section 5.3.6.6., page 198 for details of this process.

5.2.9 Post-harvesting Monitoring and Reporting

All active timber harvesting is regularly monitored by DWSP field foresters to assure compliance with both state regulations and DWSP policies for the protection of natural and cultural resources. Immediately following the completion of a timber harvesting operation, the treated area is carefully reviewed in the field by the responsible DWSP forester to assess the operator's adherence to Conservation Management Practices and other requirements of the harvesting permit. This includes a review of the operator's protection of the residual forest, soils, wetlands, and identified special habitats or plant populations, as well as the proper post-harvest treatment of access roads (back blading and the installation of water bars to divert water on steep sections), stream crossings (removal of temporary bridging materials and smoothing of approaches), and landings (removal of unutilized materials, smoothing, seeding if necessary). The Division holds a performance bond on all harvesting contractors and the return of this bond is contingent on the operator's compliance with all permit requirements.

In addition to post-harvest monitoring of operator compliance, timber sale areas are monitored for the silvicultural success of the operation. In areas expected to regenerate, regeneration surveys are conducted 3-5 years following the treatment, to assess the density and diversity of the understory response. The most common method used by the Division is to collect tree, shrub, and herbaceous information within small circular plots along transects, to determine both the success of the tree regeneration and possible competition presented by both native and alien, invasive plants. Browsing surveys are also conducted in these areas to monitor the effects of deer and moose on the forest's regeneration. Rare plant populations and wildlife utilization of unusual habitats (e.g., vernal pools) are monitored both before and following the harvest, to determine positive or negative effects.

5.2.10 Annual Reporting of Implementation Results

In advance of the annual public meeting to present progress on the plan (see Section 1.7.3), Foresters and Natural Resources Staff prepare an annual report that includes a listing of the timber sales conducted and the acres treated, a detailed description of wildlife management activities, and reports from new or ongoing research and monitoring efforts. These reports are presented to the public at the annual meeting, at which public comment is also sought for any proposed refinements or modifications to the 10-year land management plan. While it is the intent of the Division to regularly update the plan to incorporate new information either from internal monitoring efforts or from outside research, these proposed changes will only be incorporated after public review and comment have been sought through the annual meeting or a similar type of well-advertised public meeting.

5.3 Management of Other DWSP Lands

DWSP staff manages the non-forested DWSP-controlled lands in the Quabbin Reservoir's watershed system on a case-by-case basis. Presently, four non-forested areas are exceptions within the Land Management Program. These areas are non-forested lands that: 1) fall within administration areas; 2) are dedicated to the limited fishing program; 3) serve as viewsheds; or 4) are outside of the watershed itself (some parts of Quabbin Park including Quabbin Cemetery). Collectively these areas are managed in the context of the drinking water supply's watershed, but unique attributes require tailored land management approaches. The management of these other DWSP lands is briefly discussed below.

Highlights of Management of Other DWSP Lands:

1. Grounds around administration areas and the fishing areas are maintained to meet recreation and aesthetic objectives, while also addressing water supply protection issues.
2. Open lands include fields, powerline rights-of-way, gravel pits, and others total about 1,000 acres at Quabbin and are maintained for a variety of purposes.
3. 5 high use viewsheds are kept open to allow exceptional vantage points from which to view the watershed.
4. Areas within the Quabbin Park that are maintained for recreation or public access include the Visitor Center, Winsor Dam, Hank's Meadow and Goodnough Dike picnic areas, and the Quabbin Park Cemetery.
5. Access roads are critical to the security and management of the watershed lands and associated structures. Roads are categorized by width, surface material, drainage characteristics, and hydrologic sensitivity. CMPs for road maintenance and the process for spill response are detailed, as well as the internal review process for roadwork and gravel extraction.

5.3.1 Grounds around Administration Areas

The DWSP Administrative Areas are located near the Winsor Dam in Belchertown, MA. The area includes the grounds around the main Administration Building which holds the Quabbin Visitor's Center, the MA State Police Barracks, the hangar/boat launch, and staff offices. In addition, behind the Administration Building, there are garages for vehicles and engine repair and the Stewardship Forest. Nearby, in the area of the Emergency Overflow near Bluemeadow Road there are several houses serving as offices for forestry and natural resources staff and watershed rangers. Equipment and material storage is located in these restricted use areas. This area includes a large, visitor parking area typically used by cars, but also by tour buses on a seasonal basis.

5.3.2 Boat Launch Areas 1, 2 & 3

Boat Launch Area 3

Boat launch areas 1, 2 & 3 are high use recreational areas within DWSP lands in the Quabbin Reservoir Watershed system. The number of visitors to these areas is recorded; **Table 50** shows the numbers for the 2006 fishing season, when the areas were open 5 days per week. DWSP manages these areas to reduce the risks from sanitation facilities, gas and oil, aquatic plants, non-point source pollution (from vehicle parking and boat launching), and hazardous material storage (e.g., fuel for boats). Monitoring and rule enforcement is conducted by Watershed Rangers and the fishing area attendants with support from the Massachusetts State Police and Massachusetts Environmental Police Officers. DWSP staff use the Watershed Protection Regulations, 350 CMR 11.00 as well as the Division's Public Access Management Plan to guide specific management decisions in these areas.

Table 50: Boat Launch Areas - Recorded Visitors during 2006 Season

Visitor Type	Area 1 (Gate 8)	Area 2 (Gate 31)	Area 3 (Gate 43)	Totals
Shore Fishing	1,382	547	979	2,908
Private Boats	4,270	5,859	6,073	16,202
DCR Rental Boats	2,952	2,291	2,972	8,215
Fishing Licenses Sold	764	663	725	2,152

5.3.3 Maintained Open Land

Approximately 1,000 acres of open land has been created and maintained within the Division's holdings at Quabbin, either as part of an historic cultural landscape (Dana Common or Prescott Center), as openings surrounding administration areas (around buildings, Winsor Dam, Goodnough Dike, Quabbin Tower, and Hank's Meadow in Quabbin Park; around Shaft 12; fishing areas, etc.) or for wildlife habitat (open fields in Gates 12, 17, 20, 29, 45). The most recent comprehensive forest typing identified the open areas and acreages shown in **Table 51.** These areas are maintained through regular mowing or less frequent brush-mowing and/or prescribed fire.

Table 51: Maintained Open Lands at Quabbin

Type	Description	Acres
Abandoned orchard	Areas with planted fruit trees that persist despite competition, some of which are actively maintained for wildlife or ornamental purposes	8
Grass or herb cover	Land that is maintained in grasses or herbaceous cover but not associated with administrative areas	311
Upland brush	Recently abandoned fields in a wide mix of mostly brushy cover; some are maintained via occasional mowing	111
Power lines	These areas are kept open by power companies and other utilities and serve incidentally as wildlife habitat	289
Administration areas	This category includes the footprint of buildings, parking lots, and other structures, as well as mowed fields and grounds surrounding these	154
Lawns, ornamental plantings	Areas around administrative buildings within Quabbin Park, on and adjacent to dams and dikes. Dominated by mowed grass and ornamental plantings	88
Gravel pits	Areas from which gravel is currently or has been historically extracted and are not currently forested	17
TOTAL		**978**

Enfield lookout

5.3.4 Viewsheds

A viewshed is an area of land, water, or combined landscape that is visible from a fixed vantage point. The term is used widely in urban planning, archaeology, and military science. In DWSP's land management context, viewsheds are vantage points of particular scenic or historic value in the watershed that are deemed worthy of preservation. The preservation and creation of viewsheds is a secondary goal in DWSP's land management decisions and requires both forest harvesting decisions (to maintain the view) and the designation and maintenance of open space areas.

Examples of DWSP viewsheds within the Quabbin Reservoir watershed system include:

- Pelham Lookout - magnificent view of the west arm of the reservoir and Prescott Peninsula.
- New Salem Lookout - magnificent view of the north end of the reservoir and forested lands.
- Enfield Lookout - magnificent view of the reservoir's west and east arms.
- Quabbin Hill Lookout Tower – view of Mount Greylock and New Hampshire on a clear day.
- Frank E. Winsor Memorial Lookout – direct view of the Winsor Dam.

5.3.5 Quabbin Park Recreation Areas

Quabbin Park (which includes the 82 acre Quabbin Cemetery) is approximately 3,000 acres in size. The Park represents nearly 4% of the DWSP owned land in the Quabbin Reservoir Watershed system. Estimates suggest that over 80% of the recreational use in the system occurs in this 4% of the system, half of which is off the watershed. One half of the Park is located on watershed lands, and the other half, primarily the cemetery, is located on off-watershed lands.

There are many areas within the Park used by the public for passive and active recreation access, including:

- Quabbin Visitor's Center (and restrooms) located in the Administration Building.
- Winsor Dam located near the Administration building used for walking and biking. Since September 11, 2001, the Winsor Dam has been closed to general vehicle access.
- Y-Pool (Seasonal Portable Toilet) located off-watershed used for fly-fishing.
- Winsor Memorial used for bird watching, sightseeing, and picnicking.
- Quabbin Hill Lookout Tower (Restrooms and Portable Toilets) used for sightseeing, bird watching, and picnicking.
- Enfield Lookout (Portable Toilet) birding, walking, and picnicking.
- Hank's Meadow/Picnic area (seasonal Portable Toilet) used for bird watching, hiking, and picnicking.
- Goodnough Dike/Picnic area (seasonal Portable Toilet) used for walking, biking, bird watching, and picnicking.
- Quabbin Park Cemetery is approximately 82 acres in size. It contains over 6,000 graves that were relocated from the towns of Greenwich, Prescott, Dana, and Enfield.

5.3.6 Access Roads

DWSP Quabbin watershed lands include a woods road system of approximately 200-225 miles that provides vehicle access throughout most of the watershed area (some roads are being closed and allowed to return to forest cover; some occur within power line rights-of-way). The majority of these roads date to the pre-reservoir communities that were settled in this area. Some of these were well-constructed, well-drained roads that have been maintained by DWSP to varying degrees depending on priority for their usage. Others were created as simple cart paths and have since evolved to carry heavier traffic, but may not have been well-designed or placed for that purpose. At an average width of ten feet, the 200+ miles of Quabbin woods roads cover an estimated 242 acres of DWSP lands on the Quabbin watershed.

The Quabbin woods road system is essential in order to gain access for key watershed management activities including fire protection, forest management, and police patrols. The interface between roads and water resources is frequently the most likely source of water supply degradation on an otherwise stable, forested watershed. The proper maintenance of woods roads controls the deposition of sediment and organic matter into nearby tributaries, and is among the most critical land management practices conducted by the Division.

5.3.6.1 Road Categories

Quabbin's woods roads have been categorized into four types, listed in **Table 52**.

Table 52: Road Categories in the Quabbin Reservoir Watershed

Type	Road Width	Road Surface	Drainage	Maintenance Considerations	Example
Type 1: All Weather Gravel or Asphalt Roads	12 ft.-24 ft	Processed gravel or pavement	System adequate to protect roadway in most climatic conditions (50 year storm)	Type 1 roads that have a pavement surface will be swept clear of the build up of organic materials every five years. Type 1 gravel roadways will be graded annually with a road grader. Ditches and culverts will be cleared and culverts replaced as necessary. Roadside brush will be mowed yearly.	Pavement – Gate 40 road to Dana; Gravel – Gate 20 road to Lily Pond
Type 2: Secondary Gravel Roads	10 ft. - 12ft.	Processed gravel or bank run gravel	System adequate to protect roadway throughout most of the year. Most Type 2 roads will be closed during the spring mud season.	Type 2 Roads will be graded annually with a road grader. Ditches and culverts will be cleaned and kept free of debris and culverts will be replaced as necessary. Roadside brush will be mowed a minimum of once every three years	Governor's Woods Road from Gate 8 to Reservoir.
Type 3: Intermittent-use Roadways	8 ft.-12 ft.	Gravel or grass covered	System inadequate for use except when conditions are very dry.	Many of these are dead-end access roads not more than 1/2 mile in length. These roads will be mowed every three years to keep them open. Any culverts that are present, particularly at brook crossings, are inspected and maintained as necessary. Some of these roadways are situated on hillsides with a greater than 10 degree slope. Special consideration must be exercised to protect the vegetative cover and to maintain culverts and water bars on these slopes.	Gates 24 and 25 to the intersection of Gate 22 road
Type 4: Forwarder Roads	8 ft.-12ft.	Vegetative cover, impassable in all seasons except by specialized machinery	Temporary drainage systems may be used. Waterbars are used to control erosion on slopes	These dead end access roads are used only on a frequency of every five to forty years. These roadways are only used during the actual operation of timber sales; when the particular sale is finished the roadway will be stabilized to prevent overland erosion.	

A Special Category is designated for Tractor Trailer Access Roads. These roads generally include all Type 1 Roads, many of the Type 2 Roads, and some of the Type 3 Roads. They are usable by heavy equipment such as tractor trailers, which are the key design vehicle (wheel base of 50 feet chosen for design). Special considerations must be given to the maneuverability of the trailers accessing these roads; trucks must have the ability to turn around or seek other means of egress, to gain traction on steep grades, and to maneuver curves within the vehicle's tracking limits. These roads typically serve as a principal access point for very large blocks of land and therefore must be designed to accommodate a concentrated and higher volume of truck traffic with heavier loads than might be expected of roads designed for standard tri-axle logging trucks accessing smaller areas.

Examples of a Tractor Trailer Access Road include Gate 17, used to access Prescott Peninsula, and East Street from Gate 49 to the truck turnaround located on the Hardwick shoreline. The following minimum design standards shall apply to roads identified to serve as principal collectors of tractor trailer traffic.

Travel Lane Width:	11'6"
Drainage:	Crowned with ditches and relief culverts
Road Surface:	12 inches of processed gravel
Grade Limitations:	Up to 12%
Curve Radius:	41 feet (centerline)*
Curve Widening:	27 feet for 90° deflection*
Turnaround:	80 ft wide by 50 ft deep
Winter Maintenance:	Plowing/sanding specs required as part of logging permit

DWSP recognizes that the differences between standard tri-axle logging trucks and trailers may extend beyond simple physical dimensions. As tractor trailer loads are frequently 'back-hauls' of logs by French Canadian drivers, their may be language barriers as well as a lack of familiarity with the Quabbin woods road system. The Division is beginning attempts to reduce these differences through improved road signage, including identification of critical resources areas like stream crossings and the inclusion of additional site access maps in timber harvesting permits. An improved knowledge of the road system will serve to improve traffic safety and spill response capabilities.

The amount of maintenance needed on each type of roadway is difficult to predict, but is dependent on the response to weather conditions, the seasonal stability of the road, and the level of use. Site characteristics such as topography, landscape position, or proximity to wetlands also factor into maintenance requirements. The work needed to keep all major roads open throughout the year is largely dependent on the weather, and the ability to complete this work is largely dependent on the availability of labor and equipment. Major storm events affect roadways as trees or limbs fall into the roadway making them impassable. Crews are dispatched after major storm events to clear roads of fallen debris. Washouts due to culvert failure or clogged drainage ditches occasionally occur after major storms, although the Division is working to inventory and replace culverts that are undersized or have deteriorated.

DWSP is in the process of identifying specific sections of roads that will need grading work, such as the addition of bank run and processed gravel, in the next ten years. Other general road maintenance occurring on a regular basis includes annual grading of some heavily-used roads, removal of hazardous roadside trees, roadside mowing (which facilitates drainage and keeps roads open), culvert replacement and the processing and spreading of gravel as needed to maintain access or for specific land management activities.

* AASHTO, 2001. "A Policy on Geometric Design of Highways and Streets"

5.3.6.2 Criteria for Determining Hydrologic Road Sensitivity

Some of the roads the Division inherited at Quabbin were poorly located or poorly designed for handling modern log truck or tractor-trailer traffic. The Division is in the process of assessing these roads to determine which can be upgraded at reasonable expense and which are too costly to upgrade. The latter will not be maintained for truck use; the land areas that they access will either be managed by requiring that the wood be forwarded to better roads or will become inaccessible, non-management areas. The criteria currently under development for making this determination include:

1. **Dead-end roads.** Unless a turn-around of sufficient size can be developed without presenting unacceptable risk to water supplies, a dead-end road may not be useable. These roads also present challenges in managing spills, as it can be difficult to maneuver spill response equipment to the site. The filling of Quabbin Reservoir created short spur roads that dead-end at the Reservoir; however many of these have good conditions for creating truck turn-a-rounds.

2. **Grades greater than 10-12%.** Roads with grades in excess of 10-12% can present hauling difficulties for fully loaded log trucks or tractor-trailers.

3. **Physical road limitations.** In some cases, the condition of the road surface (e.g., shallow to bedrock), the absence of opportunities to move water off the road surface (for historic roads that were built or have eroded deep below the surrounding land), poor culverts that are excessively expensive to upgrade to handle a 50-year storm event, and other conditions make the road too expensive to recover to useable condition.

4. **Bridges.** If it is not known whether existing bridges are rated to at least 80,000 pounds, they are considered impassable for log trucks or tractor-trailers.

5. **Hydrologic sensitivity.** This criterion includes the hydrologic distance to the nearest intake, the hydrologic distance to the Reservoir, and the hydrologic distance to any water resource (tributaries, wetlands). The Division is still developing specific thresholds for these considerations.

6. **Critical habitats.** An assessment will be made to determine if reconditioning a road would have unacceptable impacts on critical habitats for flora or fauna. In most cases, the road has been a feature on the landscape for a long time, so that upgrading it is unlikely to cause critical additional impact. There are exceptions to this rule, especially where an upgrade would require major modifications or the addition of a turnaround near a critical habitat.

7. **Cultural/historical resource limitations.** Similar to the critical habitats criterion, the necessary road or site work to upgrade the use of the road might cause unacceptable impacts on cultural resources that have been identified in the area.

5.3.6.3 Regular Review of Access Road Maintenance Needs

The scheduling of road maintenance to coincide with the use of these roads for forest management is a difficult challenge that requires regular communication across several staff groups. Foresters propose silvicultural operations in each of the management blocks on an annual basis based on priorities in the land management plan, current markets for different species and products, and opportunities for improvements in structural diversity and species composition. A component of these proposals is the identification of access needs, which generally include maintenance or upgrades in the haul roads used to remove wood products from the landing to the main highways outside the property and in the landings themselves, in order to accommodate the anticipated equipment and truck traffic. While these proposals give the road maintenance staff an expectation of anticipated work, the scheduling of this work is complicated by the variable time required to complete the marking and selling of the proposed lots and by

the fact that the buyer is allowed to postpone starting a lot for up to two years. Therefore, regular review of priorities for access maintenance and improvement work is necessary.

The Forestry staff holds meetings every 4-8 weeks to review the status of active and pending silvicultural work, markets, changes in regulations, current problems with insects and diseases, and a wide variety of other topics. The Chief Forester will communicate identified current priorities for access work to the maintenance staff following these meetings. In addition, representatives of these two staff groups will conduct meetings in April and August to update the access maintenance priorities. While a variety of variables make it difficult to produce a fixed maintenance schedule, improved, regular communications are designed to better align priorities with availability of maintenance staff and equipment.

5.3.6.4 Pre-Planned Spill Response for Silvicultural Operations

All logging contractors who work on Division properties are licensed Massachusetts Timber Harvesters, with basic training, experience, and a good understanding of the potential threat to water supply represented by the size and weight of their equipment and by the volumes of petroleum products carried on this equipment. Log trucks and tractor-trailers typically carry up to 200 gallons of diesel fuel. Larger mechanized harvesting equipment can carry as much as 150 gallons of hydraulic fluid, as well as diesel fuel. In some situations, the Division allows fuel trucks with much larger capacities to be brought into staging areas to refuel equipment. On operations using hand felling or chainsaw bucking at the landing, chainsaw gas and bar and chain oil will also be on site, though generally in amounts of less than 10 gallons.

The most common type of spill that occurs at harvesting operations is the failure of a hydraulic line on such equipment as feller-buncher-processors or forwarders. While these machines may carry as much as 150 gallons of hydraulic fluid, the failure of one of these high-pressure hoses triggers machine responses designed to prevent high-volume spills, including automatic shutdown of hydraulic pumps or an automatic reversal to pull fluid back into the reservoir. When a spill occurs due to a failed hydraulic line, it typically results in the loss of less than 10 gallons of fluid.

All Timber Harvesting Permits on Division properties require that each piece of logging equipment carry on-board, at all times, sufficient oil-absorbent cloth to catch a ten-gallon spill, providing an immediate response to a leak or a hose failure. In addition, prior to the advertisement of a timber harvesting sale, the Division assesses the area and develops a Spill Response Plan (SRP). Where the lot can be accessed from more than one road, or from both directions on the same road, it is assumed that a spill response could be mobilized quickly from the nearest office (Belchertown or New Salem). However, if it is possible that equipment or trucks could prevent downstream access to a spill (e.g., when the only access road dead-ends at the Reservoir), a box containing oil-absorbent cloths and booms (to stretch across streams or outlets) is placed near the bottom of the access road, as well as a small boat, if required to place an oil-absorbing boom. Finally, a Spill Response Plan is included in the contract for the timber sale, which includes:

1. Locations of all wetlands, streams, culverts, and other water features within the lot.
2. A map showing access to and from the nearest public road, with the location of all wetlands, streams, culverts, intersecting roads, and areas of critical habitat identified.
3. Any limitations placed on the quantity and type of fueling permitted within the lot.
4. The requirement for a pre-harvesting meeting between Division foresters and the logging contractor to review spill response procedures.
5. Locations of permanent and temporary access roads and all staging areas.
6. Locations of spill response boxes, if these are being kept on the lot.
7. A list of phone numbers to call and procedures to follow in the event of a spill.

5.3.6.5 Conservation Management Practices for Road Maintenance

The objectives of forest road maintenance on the watershed are to provide for vehicle access to support key watershed management activities, and to minimize adverse water quality impacts associated with this road system. Activities that are dependent upon a good access road system include fire protection, forest management, and police patrols. These activities require stable, properly shaped and ditched road surfaces with adequate structures to manage storm event runoff. The vast majority of road maintenance on DWSP properties is accomplished by DWSP staff and equipment.

To accomplish these objectives DWSP crews use various mitigating procedures to protect stream water quality during routine maintenance activities. It should be noted that specific sites may require special systems not described here, such as the use of geotextiles, erosion control blankets, subsurface drainage, and rip-rap materials.

- **Shaping Road Surface.** The most basic component of a stable road is proper crowning and ditching, which allow storm runoff to leave the travel surface and be collected in the roadside ditch.

- **Relief Ditches, Relief Culverts, and Waterbars.** The frequent removal of storm water runoff from the roadside ditch is important to limit the amount of soil and gravel that is washed from an area during an event. The spacing of the relief structures is determined by combining site data such as slope of the road, slope of adjacent woodland, soil type and depth, and physical structure of the road. The general rule of thumb is to place relief structures as often as the landscape allows on most slopes. Relief structures, wherever possible, will discharge the storm runoff not less than 50 feet from streams or wetlands.

- **Sediment Traps.** These small basins will be installed where needed as part of road reconstruction activities to reduce the velocity of stormwater and to drop out larger sediments. The traps are formed by excavating a shallow depression or by placing an earthen or stone berm across a low area or swale. The traps are sized based on a target storage volume of 67 cubic yards per each acre of road drainage area. It is recommended that the sediment collected inside of the trap be removed when it has accumulated to one-half the design depth.

- **Dry Season Work.** All road work, except for emergency repair work, some major bridge work (which may extend beyond dry periods), and emergency culvert replacement, will be accomplished during dry periods (primarily summer), when low water flow and stable soil conditions will help mitigate impacts from soil disruption.

- **Use of Silt Fence/Hay Bales.** Wetlands will be protected by properly installed hay bales or industry standard silt fence whenever road maintenance work requires disturbance near these resources.

- **Seeding of Disturbed Areas.** Areas of disturbed soil will be graded and seeded with quick-growing grass species upon completion of road maintenance projects. DWSP has purchased a "hydro-seeder" for this purpose.

- **Special Road Surfaces.** Alternative road surface materials may be appropriate in limiting loss of material through erosion because of the huge variation of historical forest road construction and use. Forest roads that are rarely used may be shaped and seeded with grass. These roads would then be maintained by yearly mowing and culvert cleaning. Depending on location and use, these roads may also be blocked by use of barways to keep out all but essential traffic.

- **Stream Crossings.** It is DWSP's intention to limit catastrophic washouts by replacing under-

sized culverts with structures that will meet standards for a 50-year flood. Both culverts and ditches will be kept open and clear of all restrictions in order to prevent the back up of storm runoff and the resulting washout. In addition, DWSP will continue installation of overflow spill areas (reinforced, low areas on a road adjacent to major streams) capable of spilling the flow from a 100 year flood on major tributaries. Replacement culverts will also be chosen and designed to meet recently revised requirements for the protection of fisheries and other wildlife use of streams. The Division will design replacement stream crossings on fish-bearing, perennial streams and/or where critical habitat has been identified consistent with the fish-passage standards established under the Massachusetts Riverways Program, Massachusetts River and Stream Crossing Standards dated August 6, 2004. It is the DWSP's intent to design replacement stream crossings to the following standards:

- Crossing width should be a minimum of 1.2 times bankfull width.
- Culvert pipes should ideally be embedded to a minimum depth of one foot and a low-flow channel should be shaped within the passage.
- Work should be limited to the period from July 15 to October 1.
- Barriers to fish/aquatic life passage should be eliminated or avoided by:
  - Eliminating inlet/outlet drops
  - Avoiding constriction of flow and/or causing significant turbulence
  - Minimizing tailwater armoring.

5.3.6.6 Internal Review of Proposed Roadwork or Gravel Operations

Much of the roadwork conducted on the watershed is routine and of a maintenance nature. Occasionally, however, new access roads are constructed or raised to higher standards to accommodate more intensive use, or new sources of gravel are developed to accomplish road work. In these cases, since the operations may result in habitat changes and possible impacts on water quality, wildlife, or cultural resources, the following procedure will be followed:

- Development of a plan showing the location to be affected, time sequence of removals and procedures to be employed.

- Consultation with DWSP Section Regional Directors, Natural Resources, Environmental Quality, and the DCR Archaeologist to determine that no significant impacts will occur to water quality, wildlife, or cultural resources.

Quabbin woods road

- Consultation with and completion of all necessary approvals from the Department of Environmental Protection, the Department of Fish and Game, Division of Fisheries and Wildlife (for information on both fisheries and rare species impacts), the local town Conservation Commission, and any other governmental entity with jurisdiction over the chosen site.

- Final approval from the Director of Natural Resources.

5.3.6.7 Beaver Populations in Long-term Planning for Access

Beaver populations in the state (and throughout the Northeast) continue to increase as the number of trappers and amount of human-caused mortality remain low. DWSP constantly deals with plugging of road culverts by beaver. In some situations, DWSP has successfully installed fences and water level control devices. These solutions, however, require continual maintenance and do not offer permanent relief. Further, fencing and/or water-level control devices may not be useful in all problem situations on the watersheds. Based on research in New York State, only 3% of sites are suitable for water-level control devices (Jensen et al., 1999). In situations where water level control devices are not an option, DWSP removes beaver either by trapping or shooting individual animals. Although this solution may offer immediate relief, the habitat and conditions that attracted beaver initially have not been altered and these sites are often re-colonized within a short period of time. DWSP recognizes the limitations of these various techniques and is working to develop a long-term plan for beaver management along roads.

Recent research suggests several management techniques to protect against beaver plugging of culverts. In 81% of sites examined in New York State, culvert size (area of inlet opening) was the major determinant of whether beaver plugged the pipe. The probability of a culvert being plugged increased with decreased culvert inlet opening area. Culverts with just 8 ft^2 of area were plugged 73% of the time, while culverts with 113 ft^2 of area were only plugged 7% of the time. The design of the culvert was also an important determinant of whether beaver altered the site. Pipe-arch culverts were less prone to being plugged by beaver than round culverts. Round culverts are more likely to channel the water and reduce the stream width, alter flow rates, and generate noise that attracts beaver. Unplugged pipe-arch culverts tended to retain the natural stream width. The width of the stream at plugged culverts was twice that of the culvert inlet opening (Jensen et al., 1999).

Both research and general observations suggest that beaver are more likely to occupy sites with lower gradient and smaller width streams (e.g., first or second order), as well as abundant woody vegetation. In areas with flat topography, the total amount of woody vegetation was the primary predictor of beaver presence in New York State (Jensen et al., 1999). Because each site can be evaluated for potential beaver habitat and the probability of culvert plugging, DWSP will incorporate beaver considerations in choosing stream crossing methods. In addition to evaluating watershed area, road classification, and stream size and gradient, DWSP personnel will also consider potential beaver habitat during replacement or installations of culverts. Culverts that may already be experiencing chronic beaver plugging will be prioritized for upgrading or replacement.

5.3.6.8 Management Guidelines for Beaver at Road Stream Crossings

DWSP will incorporate beaver management considerations into road and culvert planning when possible to reduce the probability of culverts being plugged by beavers. Recommended practices include the following:

- Replace existing smaller culvert pipes with larger, oversized pipes, where feasible and applicable.
- Use box or pipe-arch culverts, when possible, with a minimum inlet opening area of 18 ft^2 (smaller sizes are easily plugged).
- Size the culvert so that that the width of inlet is at least equal to or greater than the width of the stream. This will decrease noise and minimize the potential for altering flow.
- Avoid creating a depression or pond at the inlet when installing culverts, as these are attractive to beaver.

- Do not install multiple smaller pipes at a site instead of a larger pipe. It is not a workable alternative, as smaller pipes are much more likely to be plugged.

- Utilize other management options, as needed in situations where beaver have a history of plugging even large culverts (see section 5.4.4.1).

5.4 Wildlife Management

5.4.1 Assessment of Impacts of Planned Watershed Management Activities

The management activities described in this plan will have various impacts on the wildlife community at Quabbin. Most impacts on the wildlife community will be a result of habitat changes or modifications. The forest management approach described in this plan has landscape level affects, although individual changes at any given time will be very localized and small. While the management techniques used to reach the forest management goals will not be as dramatic as historic events (1938 hurricane, flooding of the reservoir), it is important to understand how these plans will affect the habitat and wildlife communities on the watershed.

The Division's primary long-term forest management goal is to establish and/or maintain a forest cover of diverse native tree species of many different age classes on a majority of its land holdings. This goal will primarily be accomplished through uneven-aged forest management. A 20-30 year cutting cycle will be used in most areas, and harvest will be through selection of individual trees or small groups (1/20-1/4 up to 2 acres). Uneven-aged management is the best technique for preserving individual trees of high wildlife value (dens, nests, roost, mast producers) (Payne and Bryant 1994). In addition, uneven-aged management increases vertical diversity. The end result is an even distribution of a low but constant population of understory plants and associated wildlife (Payne and Bryant 1994).

Meeting this primary objective will mean wildlife communities on Division land will be dominated by species adapted to forest conditions. Those species requiring early successional or open habitat will be less common and isolated to those areas where that type of habitat exists. Open and early successional habitat will be maintained on a small percentage of the Division's land, primarily associated with developed areas (dams, dikes), beaver impoundments, and existing fields. Forest wildlife communities should benefit the most from the Division's management plan.

5.4.2 Active Management to Enhance Habitat for Selected Wildlife Species

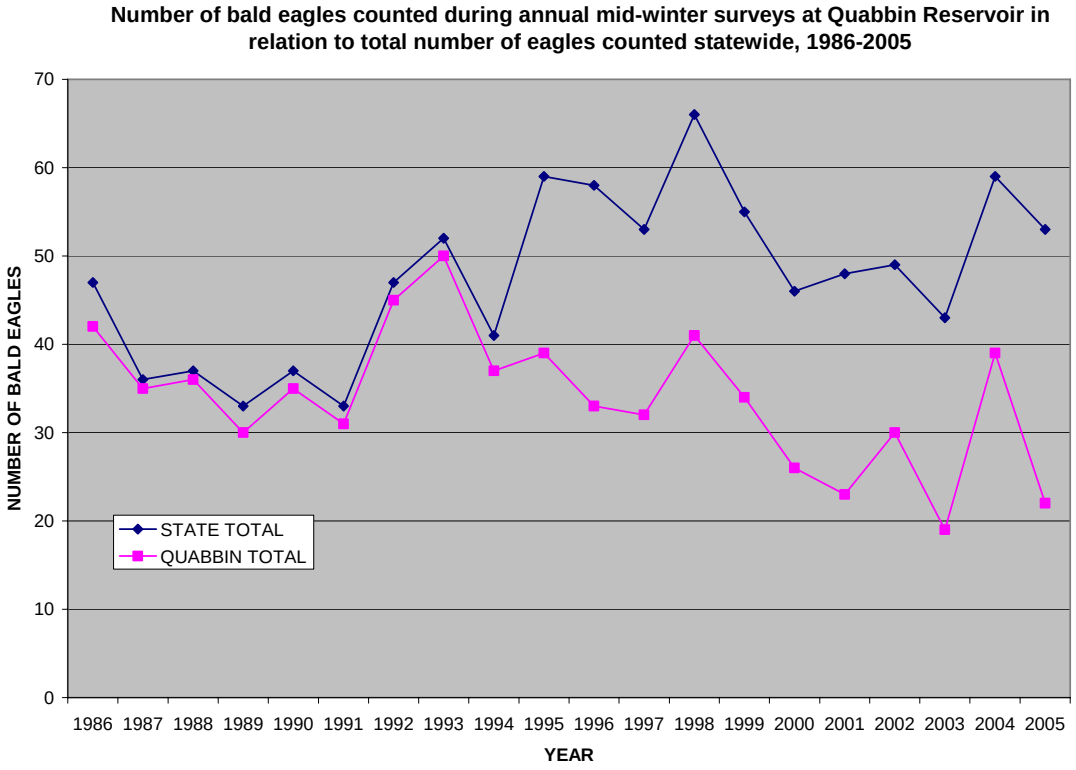
5.4.2.1 Bald Eagles

Quabbin Reservoir has played a critical role in the recovery and continued success of bald eagles in Massachusetts. From 1982 to 1988, 41 bald eagle chicks from Michigan and Canada were transported to Quabbin Reservoir and "hacked" or raised in artificial nesting platforms without human association. The efforts paid off in 1989 when 2 pairs at Quabbin produced the state's first successful breeding efforts. Eagles have bred successfully at Quabbin each year since, and anywhere from 3-5 pairs may breed annually.

Quabbin also serves as a vital wintering area for both resident and non-resident bald eagles. Because of its large size, Quabbin is often the last body of water in the state to freeze, providing open water habitat for eagles well into the winter. Annual mid-winter eagle counts have been conducted in Massachusetts since 1986 along 2 standardized routes (Quabbin Reservoir and Assawompsett Pond). Two additional routes (Connecticut River and Merrimack River) were added in 1995. In the last 20 years, Quabbin reservoir has consistently attracted more wintering eagles than any other area in the state. In fact, the

eagle count at Quabbin has accounted for 41-97% of the total number of eagles seen during the annual survey (**Figure 19**).

Figure 19: Mid-Winter Bald Eagle Counts at Quabbin Reservoir and Statewide, 1986-2005



The bald eagle continues to recover on a national level. In 1995, the Federal status of the bald eagle was changed from Endangered to Threatened. In June of 2007, the Federal government removed the bald eagle from the endangered species list. It still has federal protection through the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Its status in Massachusetts remains endangered. As a result, continued effort is made by the Division to ensure its existence at Quabbin. In cooperation with MassWildlife, buoys are placed in the water near active eagle nests to exclude fishermen and boaters from approaching too close. Each spring active nests are visited and eagle chicks are leg-banded, blood is drawn, and overall health is recorded. Leg bands provide critical survival, dispersal, and breeding information.

Finally, special attention is given to shoreline nesting and roosting habitat. When forestry operations are conducted along the reservoir's shoreline, super-canopy trees are selectively saved because these are favored by nesting eagles. In addition, other high quality potential nest trees, particularly hardwood trees with 3-pronged forks or conifer trees with a "bowl" shape near the top are saved. Lastly, consideration is given to thinning around these quality trees to ensure continued growth and allow for easy flight paths in and out of the tree.

5.4.2.2 Common Loons

There is little evidence of nesting loons in Massachusetts during the first half of the 20th century. Between 1940 and 1970 there are sporadic reports of nesting at Quabbin including one report in 1943 and another in 1959. Since 1975, loons have nested annually at Quabbin. Currently, Quabbin hosts the

largest number of breeding pairs of any water body in the state. During the 2005 nesting season, 13 pairs were present on the reservoir; 6 pairs nested, and they produced 10 chicks.

Artificial loon nesting raft

Loons prefer to nest on islands with sandy shores, low-lying vegetation, and a shallow approach that makes it easier to travel to and from the nest. Most loon territories on Quabbin have at least one potential nesting island. However, because Quabbin is a water supply reservoir, its water levels can fluctuate greatly depending on precipitation and consumer use. While loons can tolerate some fluctuation in water levels, increases of more than 6 inches or drops of more than 12 inches typically mean nest flooding or abandonment, respectively. Reservoir water levels cannot be specifically controlled during the loon nesting season. Therefore, in order to overcome potential water level problems, the Division utilizes artificial nesting rafts.

These loon rafts are constructed of dried cedar logs, wire mesh, and a camouflage canopy. Rafts are loaded with vegetation and anchored in the loon's territory each spring. During late summer, rafts are towed to shore, propped up, and stored for the winter. At Quabbin, there are currently 11 rafts in 11 different loon territories. Rafts allow nesting loons to escape fluctuating water levels. While rafts can increase loon productivity, they do not always succeed in attracting the nesting pair. There are several loon pairs at Quabbin that have a raft in their territory that still chose to nest on a natural island.

5.4.2.3 Nest Boxes for Land Birds

Some bird species may lack suitable nesting sites needed for successful breeding. While nest boxes are not a substitute for proper habitat management that provides natural snags and cavity trees, they can provide rare or uncommon species an opportunity to increase its local or regional population. As many as 50 species of North American birds are known to use nest boxes (Payne and Bryant 1994). In particular, bluebirds, kestrels, and a variety of owls respond well to the presence of nest boxes.

There are approximately 20 nest boxes located in early successional non-forested habitat on Quabbin Reservation. The boxes were originally erected to attract breeding bluebirds to the open habitats. However, many boxes need repair or to be replaced. In addition, little effort is made to adequately remove old nesting material, inspect the boxes during nesting season to remove unwanted species, or checked for insect infestations. Efforts will be made to inventory existing boxes, make necessary repairs, and monitor nesting effort during the season. In addition, other nesting boxes may be erected to attract kestrels and/or owls.

5.4.2.4 Snake Hibernacula

There is one known snake hibernaculum on the Reservation located in Hardwick in an old spoil pile that was created when one of the vertical shafts was dug. The spoil pile is essentially a huge mound of rocks and stones that provides small cavities and crevices where snakes can spend the winter. Snakes make their way through the crevices to areas below the frost line. Ideally, hibernacula face south to allow adequate sun exposure. Over time, these spoil piles grow vegetation, including large trees. The vegetation, particularly large conifer trees, can create too much shade and degrade the quality of the site. In order to restore the full potential of the hibernaculum in Hardwick, the Division removed all vegetation from the spoil pile to allow full sunlight to reach the ground. This vegetation removal will be conducted periodically to maintain the habitat.

5.4.3 Conservation Management Practices (CMPs) for Wildlife Management

DWSP foresters are concerned primarily about maintaining water quality standards and improving forest health and vigor. Monetary gain from forest resources is a minor consideration when planning management activities. A direct result of this flexibility is that it allows DWSP foresters to incorporate sound and beneficial wildlife management components into their forest cutting plans. High quality mast trees, active and potential den and nest trees, and critical habitats have been, and continue to be, conserved and encouraged on DWSP property.

CMPs for wildlife management are generally complementary to water quality protection standards. The following wildlife CMPs highlight current management techniques already being practiced and elaborate on other management techniques that can be employed.

5.4.3.1 Habitat Features and Management Recommendations

5.4.3.1.1 Vernal Pools

Management Objective: DWSP will locate and identify all vernal pools on its properties and maintain vernal pool depressions in an undisturbed state.

Recommended Practices - General:

- Seek additional input from NHESP when management activities are going to occur around a pool that contains state-listed species.
- Digitize all aerially interpreted vernal pools and provide data layer to GIS personnel for inclusion in land management activity plans.
- Identify and confirm status of photo-interpreted vernal pools.

Recommended Practices within Pool Depression:

- Continue to maintain physical integrity of pool depression and its ability to seasonally hold water.
- Continue to keep depression free of slash, treetops, and sediment from forestry operations. If slash does fall into pool during the breeding season do not remove it so breeding activity is not disturbed.

Recommended Practices at Edge of Pool:

- Keep shaded condition in 100-foot buffer zone around pool depression.
- Minimize disturbance of forest floor within 200 feet of pool edge.
- Avoid making ruts >6 inches deep within 200 feet of the pool.
- Conduct low-intensity harvests preferably when ground is frozen.

Vernal pools are contained basin depressions with no permanent outlet that typically hold water for at least 2-3 months in the spring and summer. Vernal pools may or may not dry completely each year, but their periodic drying, shallow water, winter freezing, and low oxygen levels keeps them free of fish populations.

Because of their unique characteristics, vernal pools play a critical role in the life cycles of many amphibians, reptiles, and invertebrates. As a result, the Division considers vernal pools to be critical wildlife habitats. In fact, many state-listed species are associated with, or dependent on, vernal pools. Many vernal pools dry completely during the late summer and fall and can be difficult to identify. In recent years, the Division has made efforts to locate and identify vernal pools during the spring. Accurate and detailed records of located pools, including UTM coordinates and animal use, are stored in databases. In addition, the University of Massachusetts, Amherst identified over 500 "potential" vernal pools on the Quabbin watershed through aerial photos. These pool locations have been digitized; field checking to ascertain their status is part of the on-going spring field work. Locations of documented vernal pools will be transferred to a GIS datalayer for inclusion in land management planning documents.

Vernal pool

Research is currently being conducted at Quabbin Reservation to test the effectiveness of Massachusetts Best Management Practices for vernal pools. While the state BMPs provide direct protection of the pool, there is concern that the wildlife species utilizing the pool may also rely on a larger area surrounding the pool for a majority of their life cycle. This research will test the effectiveness of the current BMPs.

5.4.3.1.2 Seeps

Management Objective: DWSP will continue to protect seeps, springs, and surrounding soils.

Recommended Practices:

- Avoid leaving slash in woodland seeps or springs.
- Maintain mast-producing trees above and around seep.
- Remove conifer trees on south side of seep; retain conifers on north and west sides of seep.
- Schedule harvests to occur on frozen ground or during the driest conditions where seeps are present.
- Avoid running heavy equipment within 50 feet of the edge of a seep.
- Use seeps, when feasible, as the center for uncut patches to retain cavity trees, snags, and other wildlife features.
- Lay out skid trails and roads in stands where seeps are present and obvious prior to the harvest.

Winter seep

Woodland seeps tend to be small (< ¼ acre) areas where ground water flows to the surface of the forest floor and saturates the soil. Seeps generally don't freeze during the winter and typically have little or no snow cover. Seeps often occur in natural depressions and may act as "seed traps" in which nuts, seeds, and fruits from surrounding trees and shrubs accumulate. This makes them important winter feeding sites for turkey, deer, and other wildlife.

Seeps provide a seasonally important source of food and water for resident and migratory wildlife (Hobson et al., 1993). These areas tend to have early sources of green vegetation. This can be an important food source for black bears in the spring and early summer. Earthworms and insects at seeps attract early migrants such as robins and woodcock. Spring salamanders and hibernating frogs, which can attract skunks and raccoons, may also use seeps.

5.4.3.1.3 Orchards and Fruit Trees

Management Objective: DWSP will save apple and other fruit trees and increase their health and vigor when feasible.

Recommended Practices:

- Continue to identify abandoned orchards and clusters of fruit trees.
- When trees are being marked for harvest, save, if possible, all fruit trees.
- Remove other trees and shrubs, when feasible, back to the drip line of the apple tree.
- Remove large over-topping trees if the fruit tree is shaded by them on at least 3 sides, particularly to the south.
- Prune and fertilize trees, when possible, at least every 3 years.

Abandoned apple orchards and scattered fruit trees exist on DWSP watershed property. Wild apple trees are one of the most valuable wildlife food species in the Northeast (Elliot 1998, Tubbs et al., 1987, Hobson et al., 1993). White-tailed deer, grouse, squirrels, fox, fisher, porcupine, and rabbits will eat apples or apple seeds. Apple trees also provide nesting and perching habitat for bluebirds, flycatchers, robins, orioles, and sapsuckers (Elliot 1998). Apple trees in abandoned orchards eventually become crowded by invading shrubs and over-topped by the encroaching forest. Prolonged crowding and shading will lead to decreased vigor and eventually death.

Young apples

5.4.3.1.4 Wildlife Wintering Areas

Management Objective: DWSP will maintain the functional value of wildlife wintering areas.

Recommended Practices:

- Identify and map all known or potential WWA using aerial photos, cover type maps, and field inspections.
- Schedule forest harvest operations within WWA, when feasible, during December-April so tree tops are available for browse.
- Protect advanced conifer regeneration during timber harvesting.
- Cut stumps low to encourage vigorous sprouting.
- Planned activities within WWA should be conducted to ensure that at least 50% of the wintering area remains in closed canopy coniferous overstory to provide functional shelter.
- Avoid concentrating harvest in any one area of the WWA.

- Try and maintain travel corridors (unbroken, dense softwood cover 60-100m wide) that connect all areas of the WWA.

Wildlife wintering areas (WWA) provide shelter and food for animals during the winter months when cold temperatures, snow cover, and limited food resources create physiologically demanding conditions. An important wintering area is often related to white-tailed deer use of concentration areas or "yards." These deer wintering areas (DWA) typically are in hemlock or pine stands where there is >70 percent conifer crown closure (Elliot 1998). Deer typically move to these areas when snow depths are around 12" (Flatebo et al., 1999). DWA provide reduced snow depths, higher nighttime temperatures, reduced wind, and greater relative humidity (Flatebo et al., 1999).

These areas must not only provide adequate cover, but also a quality supply of deer food. Cedar, red and sugar maple, birch, and hemlock are preferred foods. Another important wintering area is dense conifer cover (e.g., spruce stands) that provides increased thermal protection and wind cover for a variety of birds and mammals. For example, grouse will seek conifer stands when snow depths are <8 inches for thermal protection.

The general guideline for wildlife wintering areas is to maintain as much overstory as possible, while providing for the establishment and continued growth of preferred browse and conifer tree species.

Wildlife wintering areas

5.4.3.1.5 Mast

Management Objective: DWSP will continue to maintain and encourage a variety of mast-producing plants within the watershed**.**

Recommended Practices:

- Continue to manage stands to contain multiple species of mast-producing trees and shrubs.
- Continue to retain productive beech, oak, and hickory trees when they occur as single or scattered trees in stands dominated by other species.
- Retain beech trees with smooth or blocky bark or raised lesions to promote resistance; remove standing trees with sunken cankers or dead patches to reduce sprouting of diseased individuals. Retain some large beech trees that have potential for good mast production, regardless of disease condition.
- Lay out skid trails and roads that avoid vigorous patches of understory shrubs.
- Save all hardwood mast trees that occur in conifer plantations when practical.

Mast is a critical component of quality wildlife habitat. Trees, shrubs, and vines produce fruits, nuts, and berries called mast. Mast can be hard (nuts, seeds) or soft (fruit, berries). It contains more fat and protein than other plant foods and is actively sought by a variety of birds and mammals. In autumn, mast is particularly important as many animals will focus on eating mast in preparation for winter. Bears, squirrels, raccoons, deer, and turkey will fatten up on acorns, beechnuts, and hickory nuts. Resident songbirds such as nuthatches, chickadees, and bluejays rely on mast during winter when other food is scarce. Migrating birds will often rely on fruits and berries during migratory stops to replenish energy.

Although all trees and shrubs are defined as mast producers, some species are more important to wildlife. The value of mast to wildlife differs with the size, palatability, accessibility, nutritional content, abundance, and production frequency (Flatebo et al., 1999). In general, oak, hickory, beech, walnut, butternut, cherry, ash, and conifers are the most important mast trees. In addition, birch, hazel, alder, and aspen are also important to some wildlife species.

5.4.3.1.5.1 Hard Mast

At the Quabbin, red, white, black, and scarlet oaks are the most important source of mast. Hickories and beech comprise a relatively (< 3%) small component of the overstory. Oaks are probably the most important wildlife mast trees in the northeast. Acorns are eaten by over 100 species of birds and mammals (Healy 1997a). The frequency and characteristics of oak production varies from species to species. Red oaks produce a good crop of acorns every 2-5 years, black oaks every 2-3 years, and white oaks every 4-10 years. Red and black oak acorns take 2 years to develop, while white oaks take only 1 year. Peak acorn production begins at around 25 years for red oaks, 40 years for white oaks, and 40-75 years for black oaks (Flatebo et al., 1999). White oak acorns contain less tannin and may be more palatable to wildlife.

Beech and hickory trees comprise a small component of the Quabbin watershed forest. Hickories are scattered around the watershed and can be locally abundant in some compartments. They are also found along interior roads near former home sites. They have good seed crops every 1-3 years and begin producing quality crops at 40 years. Hickory nuts have one of the highest fat contents of any mast. Beech trees are extremely rare within the watershed, comprising less than 0.5% of the overstory. The prevalence of beech bark disease and low market demand has shifted attention away from this species. However, beechnuts can be an important source of food for a variety of wildlife. Wild turkeys prefer beechnuts to all other mast (Williamson, undated).

The seeds of maples, birches, ashes, and conifers provide food for many birds and small mammals. Red squirrels rely heavily on conifer seeds and their populations will fluctuate in response to annual crops. Birches are an important mast producer because most of the seed crop is retained on the tree above the snow. Birds, including pine siskins and grouse, count on birch seeds for their winter diet. White and red pines are the most widely distributed conifers at Quabbin. Mice, voles, grosbeaks, and finches are a few of the animals that utilize conifer mast. Chickadees and goldfinches prefer hemlock seeds.

Grapes, an example of soft mast

5.4.3.1.5.2 Soft Mast

Black cherry trees comprise a relatively small percentage of the Quabbin watershed forest canopy. However, bears, small mammals, and over 20 bird species eat cherries (Flatebo et al., 1999). Pin and chokecherries are short-lived, but provide valuable fruit to wildlife. A variety of understory shrubs and

trees produce soft mast. Blueberries, serviceberries, dogwoods, and viburnums are abundant. In addition, herbaceous plants such as blackberry, raspberry, wild strawberry, and partridgeberry, are utilized by many species of wildlife, as are grapes.

5.4.3.1.6 Wildlife Trees

Wildlife trees are often divided into two categories: snags and den trees. Snags are standing dead or partially dead trees at least 6" dbh and 20 feet in height. Den trees are live trees possessing a cavity large enough to serve as shelter for birds and mammals or a site to give birth and raise young. In general, den trees must be 15" or greater in dbh and have a minimum cavity opening of 4" in diameter (Blodgett 1985). Over 50 species of northeastern birds and mammals utilize snag and den trees during part of their lives (Blodgett 1985). Some uses of snags and den trees include cavity nest sites, nesting platforms, food cache, dwellings or dens, nesting under bark, overwintering sites, hunting and hawking perches, sources of feeding substrate, and roosting.

Forestry operations most likely have the greatest potential impact on the number, type, and location of snag and den trees at Quabbin. Thinnings, salvage, firewood cutting, and windthrow will result in wildlife tree loss. The Division's use of uneven-aged management, however, is conducive to snag management. Single-tree or group selection harvest practices will have only slight to moderate adverse impacts on snag production and retention. Although it would be ideal to salvage all wildlife trees, practical field applications make that unlikely. It is possible to maintain an optimal number of snags and dens across the watershed (**Table 53**).

Table 53: Optimum Number of Snags/Den Trees per 100 Acres by Habitat Type

	Forest Interior		Semiopen/ open	Wooded Watercourse
Tree dbh (in)	*Dens*	*Snags*	*Dens*[1]	*Dens*[1]
> 19	100	0	300	200
10-19	400	400	400	1400
< 10	200	200	300	900

[1] Animals here need den trees because creating snags by deadening trees is not recommended in these land-use types.
Source: Payne and Bryant, 1994

5.4.3.1.6.1 Snags

Management Objectives: Forestry operations will continue to provide a supply of good to excellent quality snag trees, distributed over time and space in order to maintain self-sustaining populations of all cavity dependent wildlife. In areas where good snag trees are lacking, poorer quality trees should be retained until better trees develop.

Recommended Practices:

- Leave all snags when possible, within 100 feet of wetlands and riparian areas.
- Maintain a minimum of 6 snag trees per acre; 4 should be > 24" dbh and 2 <24" dbh.
- Avoid disturbing snags from April to July to stay away from nesting birds and denning mammals.
- Leave snags in place as coarse woody debris instead of removing them if they are felled during management operations.
- Identify, when possible, current or potential snags through exterior signs such as fungal conks, butt rot, burls, cracks, wounds/scars from lightning, fire, or mechanical damage, woodpecker holes or cavities, or dead or broken limbs or tops so they can be retained.

As a tree dies, it progresses through several stages of decay (**Figure 20**) and is used by different wildlife at each stage. Newly exposed bare branches provide excellent perches for woodland hawks (Cooper's, sharp shinned), as well as flycatchers and phoebes. During the loose bark stage, brown creepers and bats may nest or roost under the bark.

As a tree deteriorates, primary excavators (woodpeckers) begin to create cavities. Almost all northeastern woodpeckers excavate nest cavities in live or dead trees. Secondary nesters then use these cavities. Once trees have decayed to a point where there are no longer branches, it is classified as a snag (< 20 feet tall is a stub). Many insectivorous birds will use the snag for foraging. Finally the snag will either topple to the ground or wear to a stump. The fallen log provides habitat for carpenter ants. In addition, amphibians and reptiles will live in and under the rotting wood; small mammals also utilize the downed logs.

In addition to the stages of decay, other variables determine a particular snag's value to specific wildlife species. Characteristics such as tree size, location, species, and how it was killed are important determinants of wildlife use (DeGraaf and Shigo 1985). In general, when managing for cavity trees, the rule "bigger is better" applies. Large birds need large diameter trees to excavate nesting cavities. Smaller birds are able to find nest sites in large trees, but it does not work the other way. In addition, large snags usually stand longer than smaller ones. Emphasis is often placed on managing for viable woodpecker populations because their success will provide enough nesting sites for secondary cavity nesters. **Table 54** gives the number of cavity trees necessary to sustain the hypothetical maximum populations of nine woodpecker species found in New England.

Figure 20: Decomposition of Snags and Coarse Woody Debris

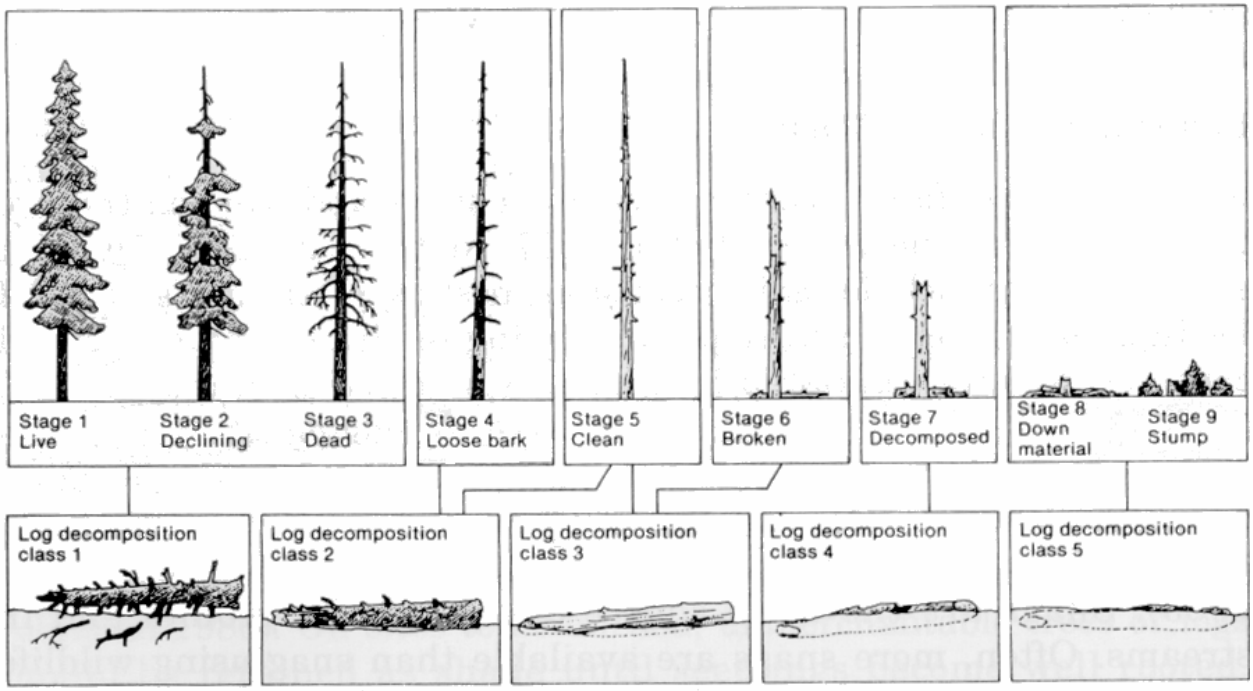


Table 54: Number of Cavity Trees Needed to Sustain New England Woodpecker Populations

Species	Territory Size (Acres)	Avg. Nest Tree[1]		(A) Cavity Trees Used, Minimum (N)	(B) Pairs/100 acres, Maximum (N)	(C) Cavity Trees Needed/100 acres[2] (AxB) (N)
		DBH (in.)	Height (ft.)			
Red-Headed Woodpecker	10	20	40	2	10	20
Red-bellied Woodpecker	15	18	40	4	6.3	25
Yellow-bellied Sapsucker	10	12	30	1	10	10
Downy Woodpecker	10	8	20	4	10	40
Hairy Woodpecker	20	12	30	4	5	20
Three-toed Woodpecker	75	14	30	4	1.3	5
Black-backed Woodpecker	75	15	30	4	1.3	5
Northern Flicker	40	15	30	2	2.5	5
Pileated Woodpecker	175	22	60	4	0.6	2.4

Source: DeGraaf and Shigo, 1985.

[1] Larger trees may be substituted for smaller trees. [2] Number of cavity trees needed to sustain population at hypothetical maximum level.

5.4.3.1.6.2 Den Trees

Management Objective: DWSP will provide a continuing supply of good to excellent quality den trees, distributed over time and space in order to maintain self-sustaining populations of all cavity dependent wildlife. In areas where good den trees are lacking, poorer quality trees will be retained until better trees develop.

Recommended Practices:

- Retain as many live trees with existing cavities and large unmarketable trees as possible.
- When possible, retain all trees > 29" dbh or at a minimum 2 or more trees >29" dbh per 100 acres.
- Leave at least 1 tree 15-29" dbh per acre.
- Leave at least 1 tree per acre that shows potential for developing into a den tree (broken top, large broken limbs, fire scar); oaks, sugar maples, ash, and hemlock are good trees to select because they readily form natural cavities or are long-lived.
- Leave all den trees within 100 feet of a wetland or riparian area.

Den tree

Den trees are living, hollow trees used by a variety of mammals including mice, raccoons, squirrels, and bears. In general, there are usually fewer den trees available in an area than could be used by wildlife because large (>15" dbh) rough or rotten trees are relatively rare.

Unlike cavity trees, which have central columns of decay, den trees are hollow or have large hollow limbs, but are still alive and vigorous. Den trees usually have easily visible openings in the sound wood. Some heavily used den trees (e.g., by raccoons) are hardwoods with the top snapped off. Den trees usually have low commercial value, but their value to wildlife is extremely high and long lasting. It may take 100 years to develop large den trees, and once developed some trees (oaks, sugar maple) can live for several hundred years (DeGraaf and Shigo 1985). Once den trees die and fall to the ground, the remnant hollow log may last 25 years, providing breeding habitat for redback salamanders and ringneck snakes.

5.4.3.1.7 Downed Woody Material

Management Objective: DWSP will continue to maintain a range of sizes and types of downed woody material and retain or provide downed woody material in sites where it is lacking.

Recommended Practices:

- Leave snags in place if they must be felled during management operations.
- Avoid damaging existing downed woody material during harvesting, particularly large (>16" dbh) hollow logs and stumps.
- Leave, when possible, at least 4 logs of decay class 1 and 2 per acre; at least 2 of these logs should be >12" dbh and >6 feet long. Hollow butt sections of felled trees can be used. (See **Fig 20** above).
- Retain as many logs as possible of classes 3, 4, and 5. (See **Fig 20** above).
- On slopes, orient logs along contours and place against stumps when possible. In full overstory removals, leave slash on at least 10% of the site in scattered piles or rows.
- Do not add debris to streams and avoid disturbing woody material already in stream.

Downed woody material refers to slash, logs, large and small limbs, stumps, and upturned tree roots that accumulate on the ground either naturally or through forestry operations. Downed woody debris provides food, cover, and nursery habitat for a range of flora, fauna, and fungi. Downed woody material provides critical wildlife habitat and is used for nesting, shelter, drumming, sunning, as a source and place to store food, and as natural bridges. The specific value of downed woody debris depends on the physical distribution, amount, size, degree of decay, and orientation of debris relative to slope and exposure (Flatebo et al., 1999). Decaying logs also serve as nurse-trees for seedlings and colonization sites for fungi. Too much or too little downed woody material can be detrimental to wildlife. In general, it is best to retain or produce downed woody material that is distributed similarly to what might occur naturally as coarse woody debris in the given stand type (often random and clumped rather than evenly distributed).

Downed woody material.

Logs are generally considered to be the most valuable downed woody material because of their slow decay and longer persistence. Long logs >16" dbh are especially important wildlife habitat features. As logs age and decay their role as wildlife habitat shifts. Logs supported by branches provide shelter, feeding, and display sites for a variety of birds and mammals. As the log settles to the ground and continues to decompose it may be used by small mammals, snakes, toad, and salamanders for shelter, food, and travel. Large logs with hollow portions may be used as den sites by larger mammals.

5.4.3.1.8 Woodland Raptor Nests

Management Objective: DWSP will maintain suitable nesting sites for woodland raptors across the landscape over time and will avoid disturbing nesting pairs of raptors.

Recommended Practices:

- Contact Division's wildlife biologist when planning forest management activities in the vicinity of a bald eagle nest.
- Inspect mature white pine and hardwood trees for large stick nests when cruising timber. Do not cut trees, when possible, containing large stick nests and hardwoods with 3-pronged forks.
- Maintain an uncut buffer of at least 66 feet around active raptor nest trees and retain 65-85 percent canopy closure within 165 feet of large stick nests in closed-canopy forests.
- Maintain an uncut buffer of at least 66 feet around nest tree if an active raptor nest is located before or during a scheduled harvest operation; do not harvest within 330 feet of the nest during April-June.
- Harvesting schedules and buffer zones may be relaxed if an active raptor nest can be positively identified as belonging to a common or tolerant species (e.g.., red-tailed or broad-winged hawk).
- Retain several super-canopy pines near the reservoir shoreline as potential future nest trees for bald eagles.
- Follow appropriate snag tree management guidelines.

Hawks, owls, falcons, and vultures are known as raptors. There are 19 species of raptors that breed in New England. Sixteen of the 19 species are known or potential breeders at the Quabbin (**Table 55**). Most raptors are predators that feed upon birds, mammals, fish, amphibians, insects, and snakes. While most raptors will eat a variety of animals, some species like the osprey have much narrower food requirements. Compared to other birds, raptors require relatively large home ranges (60->900 acres) in order to meet their food and nesting requirements. Raptor nests are widely dispersed across the landscape in a variety of habitats and forest conditions.

Some raptors will build a new nest each year within their territory, while other raptors will use the same nest for a number of years or claim the nest built by another species. Raptor nest trees must be large and strong enough to support nests ranging from 18" in diameter (broad-winged hawk) to over 3 feet (bald eagle, northern goshawk) (Flatebo et al., 1999). Large diameter broken stubs, closely spaced branches halfway up large white pines, and 3-pronged main forks of mature hardwoods are most frequently used by stick nest building raptors. By maintaining existing nests and identifying potentially good future nest trees, an area's raptor population can be maintained over a long period.

Many raptors nest early in the year. By February-March, most great-horned owls and some red-tailed hawks and barred owls are incubating eggs. Most other raptors will be incubating by May. Nesting raptors can be vulnerable to human disturbance. There is a wide range of tolerance depending on the species. Some intolerant species (bald eagles, goshawks) may abandon the nest during the early weeks of

incubation. Repeated flushing of the female from the nest may also subject the eggs to fatal chilling or the young to predation.

Identifying active nests is critical to ensuring their protection and establishing a buffer zone to minimize disturbance. The easiest, and unfortunately most infrequent, way to detect active nests is to see birds in or around the nest. However, active nests can be identified when no birds are visible by looking for the following indicators:

1. Prior to laying their eggs, some raptors 'decorate' the nest with fresh branches, usually from a conifer.
2. After hatching, whitewash (excrement), regurgitated pellets, and prey remains may be found on the ground near the nest tree.
3. Raptor nests can be distinguished from squirrel nests by their shape (squirrel nests are saucer-shaped) and lack of leaves (squirrel nests are made mostly of leaves).

Bald Eagle nest

Table 55: Known and Potential Breeding Raptors at Quabbin

Species	Breeding Status	Nest Site Selection
Turkey Vulture	Breeder	Rocky outcrops, ledges, cavities
Osprey	Potential Breeder[1]	Stick nests in trees, snags, poles
Bald Eagle[2]	Breeder	Stick nests in living trees
Northern Harrier[2]	Potential Breeder	On ground, over water
Sharp-shinned Hawk[2]	Potential Breeder	Stick nest on tree limb-usually conifers
Cooper's Hawk[1]	Potential Breeder	Stick nest (may use old crow nest) on horizontal branch in hardwood or conifer
Northern Goshawk	Breeder	Stick nest (used or new) in hardwood
Red-shouldered Hawk	Breeder	Stick nest (new) in tall tree
Broad-winged Hawk	Breeder	Stick nest in tall tree
Red-tailed Hawk	Breeder	Stick nest in oak/white pine
American Kestrel	Breeder	Cavity, nest box
Barn Owl[2]	Non-Breeder	Cavities, buildings, artificial
Screech Owl	Breeder	Cavities and woodpecker holes (Pileated/Flicker)
Great-horned Owl	Breeder	Cavities, old crow, hawk, or heron nests
Barred Owl	Breeder	Large natural cavities or old bird nests
Long-eared Owl[2]	Potential Breeder	Old crow/hawk nest or natural cavity
Saw-whet Owl	Breeder	Natural cavity or woodpecker hole
Short-eared Owl	Non-Breeder	Open fields, heath on Cape/Islands
Peregrine Falcon	Potential Breeder	Cliffs, tall buildings, urban areas

Source: adapted from DeGraaf and Rudis 1986

[1]Potential breeders are raptors not known to be currently breeding within the Quabbin watershed, but given the bird's range and habitat requirements it could breed there in the future.

[2]Listed with the Massachusetts Natural Heritage and Endangered Species Program as an endangered, threatened or special concern species.

5.4.3.2 Considerations during Timber Marking, Harvesting, and Other Land Management Activities

While careful planning and preparation can mitigate many of the potentially negative impacts on wildlife resources, some specific impacts or events cannot be discovered until operations begin in the field. Locations of active raptor nests, quality den and snag trees, and seeps may not be discovered until foresters begin marking individual trees in a lot. It is during these detailed lot inspections that some of the specific wildlife habitat management recommendations can be implemented. In addition, broader considerations such as timing of operations, harvesting techniques, record keeping, and other miscellaneous considerations should be addressed.

5.4.3.2.1 Timing of Operations

The timing of land management activities can have a dramatic impact on wildlife species. Some species (bald eagle, great-blue heron, and coyote) are extremely sensitive to human disturbance and may abandon or forgo breeding when repeatedly disturbed. Fortunately, some sensitive species can be easily identified or have known nesting sites. Great-blue herons nest in visible colonies, usually in dead snags over water. In addition, bald eagles build large stick nests that are easily seen and may be used for many years. However, for most other species their nest, burrow, or den is well hidden and would not be discovered until an operation had already begun. Luckily, most wildlife species tend to nest or den during the spring and early summer when land management activities are restricted.

When conflicts do arise, the following procedure will be followed:

1. Division personnel will notify the wildlife biologist when land management activities have clearly disrupted a rare or uncommon species' breeding efforts.
2. The Division wildlife biologist will assess/determine the nature of the nesting/denning activities, the species involved, stage of breeding (courtship, incubation, brooding), and initial response to the disturbance.
3. The Division will determine what options will be used to mitigate and avoid further disturbance during the remainder of the breeding season.

Land management activities conducted at other times of the year may unknowingly impact wildlife species, and efforts should be made to reduce these conflicts. Maintenance (mowing, burning, etc.) of fields and open areas should only be done in early spring (March/April) or after August 1 to avoid destroying nesting birds and mammals. No activity should occur in or near seeps during winter. If possible, winter activity should be avoided in and around identified wildlife wintering areas.

In some cases, activity during certain times of the year is preferred. Working around vernal pools is often best during winter when frozen/dry conditions minimize rutting and disrupting the forest floor. Further, logging during the fall and winter usually has minimal impact on most wildlife species and may actually benefit some animals by providing additional browse and cover.

Land management activities conducted at any time of the year have the potential to disrupt some wildlife species. However, this disruption is usually small in scale and scattered over the watershed. The benefits derived from actively managing the land outweigh the localized disruption. Because impacts cannot be avoided everywhere, the Division will:

- Continue to gather data on critical and sensitive wildlife and their habitats on the watershed.
- Assess the potential impacts of the timing and location of operations on a case-by-case basis to avoid impacting special concern species.
- When feasible, shift the timing or location of an operation to avoid these impacts.

5.4.3.2.2 Harvesting Techniques

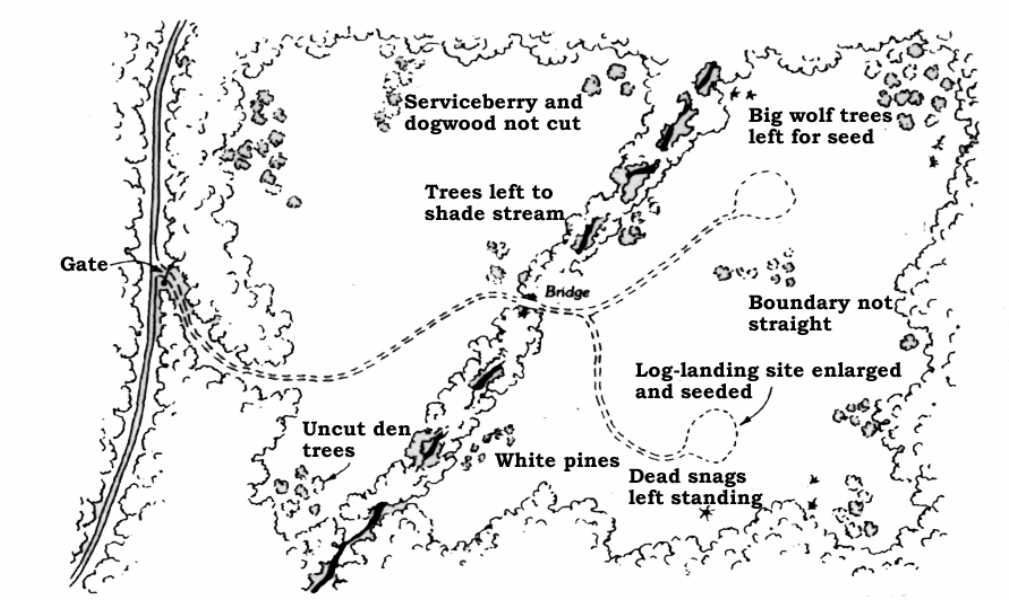
5.4.3.2.2.1 Group Selection Considerations

When forestry operations use group selection to remove trees in openings 1 acre or greater in size, certain techniques and considerations can be used to enhance the area for wildlife. With proper planning, harvesting operations can be conducted while still maintaining snags, den trees, and mast producing trees within the opening (**Figure 21;** see Section 5.4.3.1). Note that while creating an irregular border on these openings increases edge habitat and will benefit those species that prefer edges, this same phenomena may increase predation on songbird nests and increase browsing on regeneration within the opening, among other undesirable effects (Hunter, 1990).

5.4.3.2.2.2 Logging and Skid Roads

Access roads are used by the Division to remove wood, control fires, maintain watershed structures, and aid in navigation (see Section 5.3.6). Most Division roads within the watershed are narrow, grassy woods trails often referred to as logging roads. While roads are necessary to the Division, they can also act as barriers to animal movements and fragment the forest. The Division's use of uneven-aged management requires harvest operations to extend over a relatively large area and use comparatively short cutting cycles (20-30 years). As a result, an extensive network of roads are created and maintained, although careful planning can and should hold this network to a minimum.

Figure 21: Forest Opening Planned with Wildlife Considerations



The effect of forest roads on wildlife and biodiversity depends on the size, type and location of the road. The frequency with which a road is used and its proximity to other travel routes will also determine its impact. Roads effectively create an edge habitat that benefits some species, but has negative effects on species sensitive to disturbance or predators. Roads are often used by some wildlife species as travel lanes, but they may impede the movements of other species that require continuous vegetative cover. Roads may also fragment the forest and isolate individuals or populations.

Constructing and maintaining forest roads on Division property constitutes a relatively permanent change in the habitat structure of the area. Because traffic on Division roads, particularly at night, is minimal, there is little concern about direct mortality on wildlife populations. The more general concern is that a strip of dirt or gravel under an open canopy can serve as a physical or psychological barrier to animal movements (DeMaynadier and Hunter 2000). Studies have documented this barrier affect for small mammals and invertebrates (see DeMaynadier and Hunter 2000). In addition, DeMaynadier and Hunter (2000) recently documented the barrier affect of forest roads on salamanders.

When logging roads, skid trails, and landings are being planned, certain design features can be incorporated to minimize wildlife impacts:

- Logging roads/skid trails should avoid vigorous patches of shrubs.
- New logging roads should be minimized and existing roads should be upgraded instead if possible.
- Roads should be as narrow as possible, ideally one-lane with occasional turnouts.
- Circular routes should be avoided; a cul-de-sac design is better.
- Abandoned logging roads, skid trails, and landing sites should be seeded, when possible, with a grass-legume mixture.
- Road intersections should be angled to limit line of sight.

5.4.3.2.2.3 Record Keeping

Division Foresters, Rangers, and other natural resource managers spend a large amount of time walking, observing, and assessing lands within the Quabbin watershed. It is likely that they may observe

significant wildlife or important wildlife habitats. Because of the size of the watershed, these anecdotal observations are a critical source of biological information, and may be key to avoiding or mitigating potential wildlife impacts of future land management activities. These observations will be reported to the Division wildlife biologist so that records may be routinely maintained and updated.

5.4.3.2.2.4 Miscellaneous Considerations

The Division's silvicultural practices include cutting trees with weak crown forms that are more susceptible to damage. Some of these trees have wildlife value, and Division foresters should continue to leave some of these trees uncut. For example, trees growing on an angle ("hurricane-tipped") serve as travel routes for arboreal mammals from the ground to the forest canopy. In addition, older trees with large stocky limbs often have protected crotches that are used by nesting birds and mammals. These trees also typically have a high potential for cavity formation. While it is not necessary to maintain all examples of these trees, it is important to retain some during harvesting operations.

Particular combinations of trees species are also valuable to wildlife. Mature oak trees within hemlock or other conifer stands provide food resources within wildlife wintering areas. Small pockets of hemlock within hardwood stands can serve as significant wildlife cover. Both of these habitat conditions should receive special treatment when feasible.

5.4.3.2.3 Natural Heritage and Endangered Species Program Conservation Management Practices for Listed Wildlife Species (WCMPs)

The Natural Heritage & Endangered Species Program (NHESP), in collaboration with DCR's Division of Water Supply Protection, DCR's Bureau of Forestry, and the Massachusetts Division of Fisheries and Wildlife's Forestry Program, is currently preparing wildlife conservation management practices (WCMP) documents for certain rare species that are listed and protected by the Massachusetts Endangered Species Act (MESA). These WCMP documents will provide information on the rare species' life history and habitat requirements and make scientifically-based recommendations on how to minimize potential adverse impacts of forestry activities. The goal of these recommendations is to protect rare species populations and maintain rare species habitats for long-term viability while maintaining the opportunity for the sustainable management of the state's forests.

The rare species information forming the basis of these documents has been gathered from a variety of sources. Information on specific rare species and their habitat requirements has been compiled from published scientific articles, books, unpublished reports, NHESP data, existing management guidelines from other states, and consultation with researchers who have first-hand experience with the species in Massachusetts.

The NHESP will use these recommendations in its review of specific Forest Cutting Plans. The existence of the WCMPs will improve the speed and consistency of the NHESP's reviews of Forest Cutting Plans and will make the outcome of the Cutting Plan reviews more predictable to the forestry community. These recommendations do not supersede any law, regulation, or official policy of this or any other agency. Rather, these guidelines are intended to complement existing regulatory review processes by providing up-to-date, scientifically-based management recommendations for forestry activities as they impact specific species.

Although the best available scientific information, researchers, and managers were consulted in preparing these documents, it is expected that new information will arise about the species' requirements and their response to habitat modifications. With the recognition that both forestry practices and rare species conservation require adaptive management it is acknowledged that the recommendations in these documents may need to be updated and revised in the future.

5.4.4 Population or Impact Monitoring and Control Plans

5.4.4.1 Beaver

5.4.4.1.1 Aquatic Wildlife Pathogen Control Zone

There is extensive research documenting the role of certain wildlife species in the transmission and amplification of water-borne pathogens. In order to address these concerns, the Division developed a control program to identify, remove, and study critical wildlife species from a defined area around the Chicopee Valley Aqueduct (CVA) Intake (for a complete description of the program see **Quabbin and Wachusett Reservoir Watersheds Aquatic Wildlife Pathogen Control Zones,** MDC 1999).

The program began in 1999, and it specifically targets beaver and muskrat populations living within the defined control zone (the cross-hatched area in **Figure 22**). Routine surveys are conducted within the zone, and any individuals of beaver or muskrat that are located are immediately removed. In addition, other activities are conducted to discourage animals from occupying the sites, including habitat modification and removal of lodges and dams. Control activities take place year-round through a special agreement with MassWildlife.

Since 2004, fecal samples have been collected from removed animals. Samples are tested for the presence of *Giardia spp.* and *Cryptosporidium spp.* Early results of this ongoing study indicate a relatively low rate of infection.

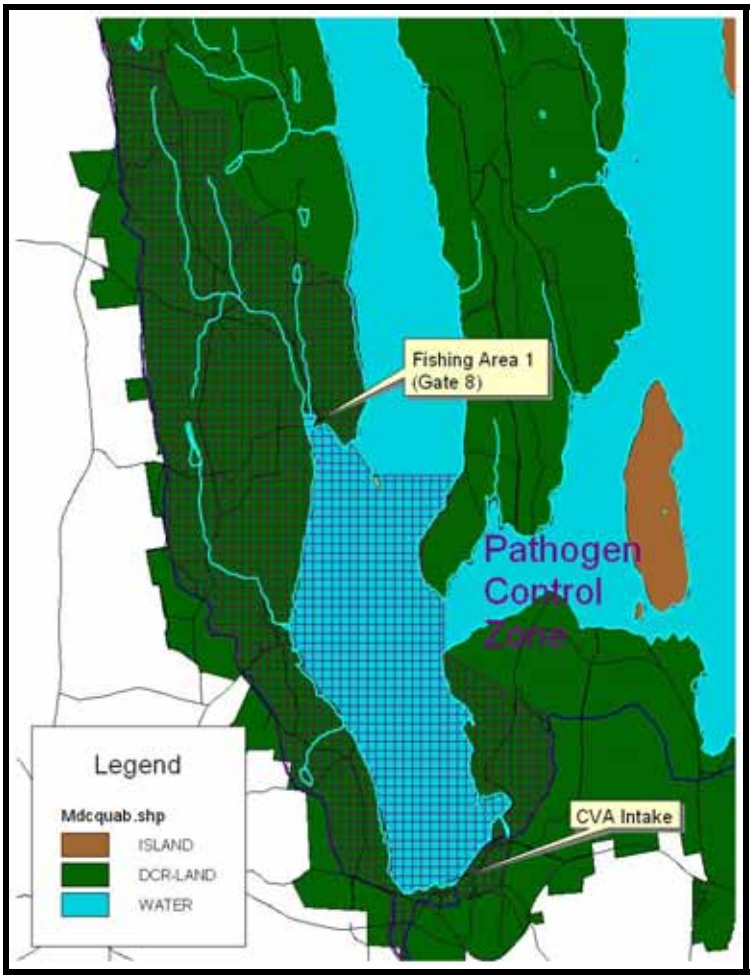
5.4.4.1.2 Beaver Sites outside the Pathogen Control Zone

Beaver can dramatically alter their surrounding habitat, which in turn can affect other wildlife species and humans. Beaver can cause localized damage to roads, culverts, and trees, although the habitat they create is seen as beneficial to a variety of wildlife species. Whether any one colony is seen as beneficial or detrimental depends on the resources affected. Division policy regarding beavers takes into account the variety of situations that may arise and applies solutions as needed to offer the best long-term remediation. Because beaver issues can become quite controversial, it is important to present the range of potential beaver impacts on riparian vegetation, water quality parameters, and the general ecology.

5.4.4.1.2.1 Beaver Induced Alterations of Riparian Systems

Beaver are one of the few wildlife species that have the ability to dramatically alter the surrounding habitat to their benefit. These habitat alterations can have potentially substantial impacts on the ecosystem. Changes in vegetation, biotic and abiotic features of the wetland, and impacts to other organisms may result. Riparian areas, particularly second- to fourth-order streams and adjacent low-lying areas are often colonized by beaver (Hammerson 1994). The presence or absence of beaver in an area or region can have a dramatic impact on the predominant vegetation. For example, in West Virginia, the widespread swamp forests common in the early 1900s were most likely the result of the eradication of beaver from the state by the early 1800s (Land and Weider, 1984 in Hammerson 1994). Most Division owned riparian areas are primarily forested with a variety of tree species. It is interesting to note that these forested wetlands in Massachusetts may also be an artifact of the beaver's eradication from the state by the late 1700s until their eventual return in 1928. As a result, changes to the riparian landscape caused by expanding beaver populations during the last 20-30 years may appear even more dramatic because they were absent from the ecosystem for many decades.

Figure 22: Pathogen Control Zones at Quabbin



The Division's primary interest is to preserve and protect water quality within the water supply reservoirs, and riparian areas are an important component to that protection. As a result, it is helpful to summarize the impacts of beaver on the biotic and abiotic components of riparian ecosystems in order to address potential negative impacts from their occupation of riparian areas. One of the most important factors related to changes in the environment is the structural integrity of beaver dams. Many of the components associated with beaver occupation of riparian zones are contingent on the longevity and stability of the dam itself. Dams that continually wash out may cause water quality problems associated with flooding and the sudden release of sediment and accumulated nutrients. It is usually dams on larger streams (above fourth-order) that are prone to washouts (Naiman et al., 1988). Many of the streams within the Quabbin watershed are first- to second-order streams, although there are larger streams (East and West branches of the Swift River) that are fourth- to fifth-order streams. Any beaver dams located on these higher order streams would be much more prone to wash-outs.

5.4.4.1.2.2 Beaver Effects on Vegetation

Beaver are strictly herbivores and have been described as choosy generalists (Novak, 1987). Beaver are also central place foragers because they return to their lodge or bank den after feeding (Naiman et al., 1988). This is a critical behavioral trait and, as a result, beaver foraging is restricted to a relatively narrow band of forest surrounding their pond (Johnston and Naiman, 1990). One study indicated that beaver fed preferentially on a few number of deciduous species and the number of stems cut declined sharply as distance increased from the pond (Donker and Fryxell, 1999). Barnes and Mallik (2001) found that 91%

of all beaver cut stems were within 20.1 m of the pond shoreline. Beaver will cut and consume a variety of woody vegetation in addition to feeding on aquatic vegetation during the spring and summer. Beaver do have a strong preference for certain species, particularly members of the aspen family.

When beaver colonize a new riparian area, several important events take place. Typically, a dam is constructed, and the raised water level kills trees within the flood zone. In addition, beaver cut down some trees along the shoreline. Although a substantial number of trees may be lost due to flooding, the wetland continues to be buffered by a forested habitat. The forested zone has been pushed back to where the high water level now occurs as opposed to lining the stream bank. Along the shoreline, some canopy trees are killed or toppled by beaver, allowing more light to reach the forest floor. Increased light, along with a decrease in competition for water and nutrients, will stimulate regeneration and a release of the forest understory (Johnston and Naiman, 1990). The light penetration may be sufficient to allow regeneration of shade-intolerant species (Donker and Fryxell, 1999). The amount of canopy being removed along the shoreline can vary. After 6 years of continuous occupation, one study site had a 43% reduction in basal area of stems >2 inches dbh (Johnston and Naiman, 1990). Other studies have indicated that perceived damage and actual damage to forest resources may be quite different. King et al., (1998) indicated that beaver in a wetland in the southern United States were having minimal effect on the forest. In this case it was determined that although tree damage was highly visible by casual observation, beaver were having little impact on tree survival.

In some cases where the overstory is primarily comprised of aspen (some western streams), a majority of the overstory may be removed, and the riparian area could go through a shrubby woody stage until non-browsed species grow and overtop the shrub layer. On the Quabbin watershed, aspen species are a relatively minor component to forested riparian areas. Most riparian areas consist of a diversity of species, making it less likely that all trees will be removed, although the shrubby component to the riparian area may become more dominant as some canopy trees are lost.

Beaver induced changes to vegetation along riparian zones can be quite dramatic when compared to conditions prior to beaver occupation. The primary result of these changes will be a shift in the species composition before and after beaver occupation. The shift may be undesirable if the species being lost are of high economic value (pine, oak, etc.). This is a particular problem in many southern states. In summary, the riparian wetland, although different, is still buffered by a forested habitat that may be more diverse and/or contain a larger shrubby component.

5.4.4.1.2.3 Beaver Effects on Water Quality

The Division manages beaver within the defined Aquatic Wildlife Pathogen Control Zone to control pathogen transmission (see Section 5.4.4.1.1). However, because beaver can alter the hydrologic regime of a riparian area, it is important to consider their impact with regards to general water quality parameters. As mentioned in Section 5.4.1.2.1.1, most streams within the Quabbin watershed are low-order (first-to-third) systems, and beaver dams constructed in these sites are most likely to exist in stable conditions for many years.

In many situations, beaver dams can transform a lotic system into a lentic habitat that may resemble a lake or pond*. Some important changes associated with this transformation include increased water depth, elevation of the water table, an increase in the wetted surface area of the channel, and storage of precipitation, which is gradually released (Hammerson 1994). In addition, the storage of precipitation can reduce variability in the discharge regime of the stream (Hammerson 1994). Ponded riparian areas have an increase in aerobic respiration. Respiration is 16 times that found in a riffle (per linear meter of

* Lotic refers to aquatic communities found in running water. Lentic referes to aquatic communities found in standing water.

channel) (Hammerson 1994). In low-order streams there is a shift to anaerobic biogeochemical cycles in soil layers beneath the aerobic pond sediments (Hammerson 1994).

Ponded areas behind beaver dams reduce current velocity within the riparian area, which decreases erosion and stabilizes streambanks (Brayton 1984, Hammerson 1994). In some western states beaver were introduced into riparian ecosystems that had eroded streambanks and little vegetation along the shoreline (Brayton 1984). The result was a dramatic decrease in sediment transport downstream, streambank erosion was stabilized, and diversity of vegetation began to grow (Brayton 1984). In addition, by slowing down water velocity there is increased trapping of sediments behind beaver dams, and a resultant decrease in turbidity downstream (Brayton 1984, Hammerson 1994, Maret et al., 1987, Naiman et al., 1994, Naiman et al., 1988). Several studies have shown a substantial amount of sediment being collected behind beaver dams, ranging from 1.5-6 feet (Hammerson 1994, Meentemeyer and Butler 1999). Meentemeyer and Butler (1999) suggest that if beaver are eliminated from a landscape, basin sediment yields could increase dramatically. Having beaver present in a watershed in turn would help minimize sediment transport and stabilize stream banks (Meentemeyer and Butler 1999).

Changes in the chemical and physical properties of the stream occur when an area is dammed. Generally there is a reduction in Dissolved Oxygen (DO), Aluminum (Al), and Sulfate (SO_4^{2-}), and an increase in pH, dissolved organic carbon (DOC), Iron (Fe), and Manganese (Mn) (Smith et Al., 1991; Hammerson 1994). DO reduction was most likely the result of increased retention of organic matter and associated decomposition processes (Smith et al., 1991). By trapping large amounts of sediments and particulates, beaver ponds can also trap associated nutrients, including phosphorus (Maret et al., 1987). Phosphorus (P) is an important element in water supply reservoirs because it is often the limiting factor in the growth of aquatic plants and algae in reservoir systems (Lyons 1998). Other studies have shown that beaver activities may actually increase concentrations of P within the impoundment (Klotz 1998). However, in these studies it is clearly shown that increased concentrations of P only occur for short distances downstream of beaver ponds before equilibrium processes reduce the concentration (Klotz 1998). .

One potential problem associated with beaver is the increase in DOC within the beaver pond. Though DOC does not directly affect drinking water quality parameters, it is a concern because of disinfection by-products. DOC in beaver ponds increases for several reasons. First, a large amount of wood is transferred into the stream channel, either directly through cutting or indirectly through flooding. In addition, more leaves are collected within a pond than in a stream channel. The carbon turnover rate for this material is less in a ponded area than in a stream with flowing water Hammerson 1994). Margolis et al., (2001) found average DOC concentrations 10 m and 100 m downstream of a beaver impoundment were significantly higher than DOC concentrations upstream of a beaver pond or 1 m below the impoundment. Although increases in DOC are a potential concern, a recent study conducted at Quabbin suggested that biological processes and the sheer size of the reservoir prevented these elevated DOC levels from reaching the intake (Garvey 2000). In fact, this study suggests that algae are a much greater concern regarding disinfection by-products at reservoir intakes.

The overall effect of ponding riparian areas is the translocation of chemical elements from the inundated upland to the pond sediments or downstream. A portion of the chemical elements are transported downstream, while most are accumulated in the pond sediments and are available for vegetative growth if the pond drains and succession begins (Naiman et al., 1994).

5.4.4.1.2.4 Ecological Impacts of Beaver

There are ecological impacts as the beaver transforms the stream channel into a ponded area. The most immediate effect could be the potential loss of habitat for species either requiring large expanses of deciduous trees along a stream or those species living within the stream channel. Because a beaver dam influences only parts of a riparian area, it is unlikely that beaver activity would result in the disappearance

of species relying on wooded streams. In New York, experts agree that even after 30 years of expanding beaver populations, species or communities requiring wooded wetlands were probably not adversely affected on a regional or statewide level (Hammerson 1994).

There is often a good deal of concern regarding cold water fisheries and the impacts of beaver impoundments. It is likely that beaver both enhance and degrade suitable fish habitat. Hägglund and Sjöberg (1999) indicated that beaver enhance fish species diversity in Swedish streams. In addition, they speculate that beaver ponds serve as habitat for larger trout in small streams during drought periods. Snodgrass and Meffe (1998) indicated that in low-order streams, beaver had a positive effect on fish species richness. The maintenance of this effect however required the preservation of the dynamics of beaver pond creation and abandonment. The warming of stream water is often cited as a cause of concern regarding cold water fish habitat. A study done in Maryland and Pennsylvania reported that water temperatures were significantly greater downstream of beaver dams during the fall, spring, and summer (Margolis et al., 2001). McRae and Edwards (1994) indicated that large beaver impoundments would often warm downstream temperatures slightly, but they also served to dampen temperature fluctuations immediately downstream. In addition, when beaver dams were experimentally removed, there was no reduction in the difference between upstream and downstream temperatures. In some cases, dam removal increased the warming rate of the stream (McRae and Edwards 1994). It has been suggested that air temperature (not impoundments) is the single most important determinant of stream temperature in the absence of direct thermal inputs (McRae and Edwards 1994).

The impact on other organisms is less understood. Russell et al., (1999) reported that species richness and abundance of amphibians were not significantly different among old beaver ponds, new beaver ponds, and unimpounded streams. Reptiles did show a difference among sites. Richness and total abundance of reptiles was significantly higher at old beaver ponds (Russell et al., 1999). Another study found no significant differences in overall herpetofaunal abundance between uninterrupted streams and beaver ponds (Metts et al., 2001). However, significantly more salamanders were captured at uninterrupted streams and significantly more anurans, lizards, and turtles were captured at beaver ponds (Metts et al., 2001).

Invertebrate communities exhibit a strong ecological shift as running water taxa are replaced by pond taxa when streams are impounded. This results in an increase in the number of collectors and predators and a decrease in the number of shredders and scrapers (Naiman et al., 1988). While total density and biomass may be 2-5 times greater in ponds than riffles, the total number of species in ponds and streams appear to be similar (Naiman et al., 1988).

5.4.4.1.2.5 Summary

Beaver populations within the Quabbin watershed continue to fluctuate as beaver mortality rates remain low. As beaver continue to colonize riparian areas, it is important to recognize their role in hydrologic and ecological processes. A careful review of the literature would indicate that it is not the presence of beaver dams themselves but their persistence through time that has the biggest potential impact on water quality. The results of one study suggested that beaver ponds could improve water quality if they were located in the right locations; the authors deduced that it is the downstream channel that has the largest impact on water quality: “Our data illustrate the importance of location of beaver ponds along a stream in improving water quality. If water quality is to be maintained downstream from ponds and if nutrient export to a lake or reservoir is to be reduced, then the channel downstream from the pond complex must be stable or the pond complex must be located close to the lake or reservoir”(Maret et al., 1987). Most streams within the Quabbin watershed are low-order (first to third), and beaver dams constructed across these streams have the strong potential for long-term stability and persistence. On those sites with historically unstable beaver dams or on particularly “flashy” streams, beaver control will be addressed as described in section 5.4.4.1.3.

Some water quality parameters are changed or modified when beaver dam riparian areas. Generally, there is a reduction in DO, and an increase in DOC, pH, and Fe. Some studies have suggested that these changes may carry at least 100m downstream of an impoundment. Most evidence would suggest that beaver ponds (like most wetlands) have either no negative effect on water quality or have a filtering effect that improves water quality by decreasing erosion, trapping sediments, particulates, and nutrients. Changes to vegetation along the banks of beaver ponds results in a species shift away from species preferred by beaver or economically valuable deciduous trees to a larger proportion of woody shrubs and unpalatable or undesirable (by beaver) canopy trees. The more open canopy that results from beaver activity stimulates regeneration and increases habitat diversity.

Overall, there appear to be either no effects or positive effects on both faunal species richness and diversity when comparing ponds to unaltered riparian wetlands. There are still site-specific situations where beaver will need to be controlled as detailed in the next section. Outside these specific situations where damage is occurring, there does not appear to be a need for the Division to focus beaver control efforts on a watershed basis.

5.4.4.1.3 Beaver Management Policy

It is the Division's general policy to allow unrestricted beaver occupation. However, the following situations are examples where beaver activity may be discouraged, mitigated, or modified:

- Beaver activity that threatens rare or uncommon plant or animal communities.
- Beaver activity that precludes the use of necessary access roads needed for watershed maintenance, management, or protection.
- Beaver activity that threatens the proper functioning or structure of dams, culverts, and other parts of the water supply infrastructure.
- Beaver dams on unstable or flashy streams with a history of, or potential for, regular washouts.

The following procedure will be used to mitigate the damage when there is a conflict with a beaver colony. Division personnel encountering problem beaver sites should fill a *Beaver Damage Observation Form* and return it to the Division wildlife biologist and Quabbin/Ware River Regional Director. Upon review, the wildlife biologist and Regional Director will decide the most appropriate control activity for each site. Options available include: water level control devices, dam stabilization, culvert protection, or lethal removal. Site-specific control options will be chosen based on site conditions, history of the site, and type of damage occurring. The goal is to provide the most effective control possible that mitigates the problem. Appropriate permits will be obtained when necessary (e.g., removing a section of dam to install a flow control pipe).

Lethal removal will be a viable option, but will only be used if all of the following criteria for the site are met:

- Beaver are causing documented (observation, photographs, etc.) damage to DCR infrastructure (roads, culverts, bridges).
- Other, non-lethal means (water level control devices, fencing, etc.) would not be able to mitigate the problem because of limitations in access, maintenance, or effectiveness.
- DCR property being damaged is essential and cannot be temporarily abandoned.

- Lethal measures can be implemented within appropriate laws and guidelines and without threat to the safety of the public, domestic animals or other wildlife.

When lethal measures are to be used, the following procedure must be followed:

- The above criteria must be documented prior to action (using *Beaver Damage Observation* Form).

- Beaver will be removed through shooting (12 gauge shotgun), or live-trapping during the beaver trapping season using Hancock, Bailey or cage traps and then shooting.

- Two staff will be present at all time and will include one supervisor. The supervisor will be a Water System Storage Foreman II or higher. All staff participating will have a Firearms ID card. Any persons using live-traps must be properly trained.

- Every attempt will be made to retrieve beaver carcasses, and upon retrieval a fecal sample will be collected and then the animal will be buried at a suitable location.

- Personnel taking part in beaver control activities will take adequate precautions (washing hands/wearing rubber gloves) to prevent possible transmission of *Giardia* and *Cryptosporidium* and other pathogens.

- The supervisor in charge will document all actions and complete the proper *Beaver Removal Documentation Form*, of which copies will be sent to the Wildlife Biologist and Regional Director.

5.4.4.2 Birds

5.4.4.2.1 Gulls

Quabbin Reservoir provides a nighttime roosting site for a variable number of gulls throughout the year. In addition, a small number of gulls will use the reservoir during the day as a loafing and resting area. Herring, ring-billed, and great black-backed gulls are the most common species. Gull numbers begin to increase during the late summer and continue to increase throughout the fall. During winter, numbers can grow substantially and usually reach their peak when all other local bodies of water have frozen but Quabbin remains open. It is not unusual to have as many as 2,500 birds roosting each night. By spring and early summer, most gulls have left the area and returned to their breeding sites along the coast (herring and great black-back) or to interior nesting lakes (ring-billed).

Roosting gulls typically leave the reservoir soon after sunrise and disperse to spend the day feeding at landfills, agricultural areas, large open fields, or at various shopping malls and parking lots. By late afternoon, gulls begin returning to the reservoir to roost for the night.

The Division has been monitoring gull populations at Quabbin since 1990. Gull populations and water quality parameters were studied in the early 1990s. Water quality sampling analysis determined that roosting gulls were responsible for an associated increase in fecal coliform counts. In response to this information, the Division initiated a gull harassment program in 1992. The program has been conducted yearly since and uses a combination of pyrotechnics and boats to harass and move birds away from the CVA. Harassment activities typically begin by October each year. Up to 3 boats are deployed each night to chase and harass gulls that are present within the gull harassment zone (**Figure 4**). Boats are on the water from late afternoon until after sunset. The program is administered by Environmental Quality staff

within the Quabbin section. The labor staff is responsible for operating the boats and firing the pyrotechnics.

Figure 4: Quabbin Reservoir Gull-free Zone

Control efforts during the active harassment period of the program are conducted 7 days/week until the reservoir freezes or birds disperse in the spring. When ice or weather prevents boats from being deployed, harassment occurs from strategically placed personnel on shore.

In addition to the gull harassment program, the Division has participated in efforts to control gulls at landfills. In 1998, the Department of Environmental Protection instituted regulations that required all municipal solid waste landfills to harass and discourage gulls from loafing and feeding at their sites. New landfills must submit a written gull harassment program prior to receiving their operating permit. In conjunction with these regulations, Division staff has assisted landfills in developing harassment plans and also aided landfills in actively harassing gulls.

Activities related to the gull harassment program that will take place during the next 10 years include:

- Make weekly observations of gulls roosting on the reservoir to determine numbers of birds, species distribution, flight paths, and behavior.
- Continue to monitor landfills to assess the effectiveness of harassment programs.
- Continue to investigate and document alternative sources of food for regional gulls, including agricultural areas, composting sites, and wastewater treatment facilities.
- Develop, when and where appropriate, new methods or techniques of harassing or discouraging gulls from critical areas of the reservoir.
- Initiate a comprehensive study of gull movements and biology using satellite telemetry.

5.4.4.2.2 Geese

Resident Canada geese are present at Quabbin Reservoir year round; they will leave the area when the reservoir freezes. In addition, during the fall and winter, migratory geese will also utilize the reservoir. While geese are much fewer in numbers than gulls, they still represent a priority management species and are actively harassed during the bird harassment program.

Since 1999 the Division has conducted a resident goose population control program at Quabbin Reservoir. Each spring efforts are made to locate geese nesting on the reservoir. Once identified, eggs in each nest are treated to prevent hatching. The long-term goal of this program is the gradual reduction in the resident adult goose population. In addition to efforts to locate and treat nests close to the CVA, (**Table 56**), this program now includes an extensive search of all reservoir islands.

Table 56: Number of Canada Goose Nests and Eggs Treated 1999 -2007, to Prevent Hatching

Year	# Nests	# Eggs Treated
1999	8	37
2000	10	37
2001	9	41
2002	7	36
2003	7	36
2004	7	34
2005	3	11
2006	9	43
2007	6	34

5.4.4.2.3 Other Waterfowl

A variety of other waterfowl utilize Quabbin Reservoir at various times during the year. During the spring and summer, there is a relatively small number of resident mallard ducks that nest on islands. During the fall and winter, the number of waterfowl can increase substantially as migrating birds use Quabbin as a rest stop. Ring-necked ducks, common mergansers, common goldeneyes, and other species can all be found on the reservoir during the fall and winter. All species of waterfowl are included in the harassment efforts if they are located within the bird harassment zone.

5.4.4.3 Burrowing Animals

The burrowing activity of certain wildlife species such as woodchucks, moles, and voles can cause damage to the integrity of earthen dams, dikes, and other watershed structures. Woodchucks have been a recurring problem along Winsor Dam in the past few years. Both lethal methods and live-trapping have been used to remove these problem animals. DWSP is working to develop long-term management techniques to discourage reoccupation.

5.4.4.4 White-Tailed Deer

White-tailed deer populations are increasing in most of the northeast. There is growing concern about these increasing populations and their impact on natural resources (Healy 1997a, Healy 1997b, Alverson and Walker 1999, McShea and Rappole 1997). Deer populations within Massachusetts are increasing in the central and eastern part of the state (MassWildlife, pers. comm.). White-tailed deer can thrive in suburban environments where there is abundant food, few predators, and enough wooded areas to provide cover. Coupled with expanding deer populations is increased fragmentation of the landscape that can isolate these wooded reserves and in many cases prevent people from effectively hunting white-tailed deer populations. Even in areas where hunting is feasible, there is growing concern that both hunter interest and hunter recruitment is declining. In many situations, these circumstances can lead to overabundant deer densities.

Overabundant deer populations can influence and affect the abundance of woody species (Walker and Alverson 1997). In addition, intensive deer browse may cause problems in regenerating particular species such as oak. When deer populations are protected for many years and sustained at high densities, forest structure may be altered completely, resulting in park-like stands with grass or ferns dominating the understory (Walker and Alverson 1997). Situations like this were documented on the Quabbin Reservation and in the Alleghany National Forest in northwest Pennsylvania (Walker and Alverson 1997). In response to growing concerns about the lack of forest regeneration and the absence of an understory layer within large portions of Quabbin Reservation, the area was opened to limited, controlled public deer hunting in 1991. Hunting has been conducted on the reservation each year since.

The controlled hunts constituted only one component of a comprehensive 1991 White-tailed Deer Impact Management Plan for the reservation that also included the use of electrified fencing and various changes in the Division's land management program. That plan called for six years of controlled hunting, followed by a major review and re-evaluation of the program. That review was conducted in the spring of 1997 when two reports (*Quabbin Regeneration: Summary Report 1988-97* and *Quabbin Reservation White-tailed Deer Impact Management Program: Results and Evaluation 1991-1996*) were issued by the Division. Also at that time, recommendations for the next phase of the program were issued in the document *Quabbin Reservation White-tailed Deer Impact Management Program: Summary Report and Proposal 1997*. Those recommendations called for a continuation of the controlled hunting program with several changes proposed to make the program more efficient.

The driving force behind the deer reduction program has always been to reduce the impacts of deer browsing to a level that allows and promotes the development of a healthy, resilient, diverse forest that can adequately and continuously protect water quality. Major components of the deer population reduction program were to: 1.) Reduce population densities; and 2.) Maintain those densities at a level that allows for the continued growth and regeneration of forest tree species.

After several years of controlled hunts, substantial reductions in deer population densities were achieved in all hunt areas, and the Division has been in the maintenance phase of its program for several years. The maintenance phase of the program is essential for maintaining relatively stable deer population levels and eliminating potentially large swings in deer densities that could occur if hunting were stopped for an extended period of time. In the absence of regular hunting mortality, deer populations at lower densities that have little natural mortality and an increasing food supply would expand and could jeopardize the forest regeneration progress made to date. In 2000, a five-year plan was developed that outlined proposed activities for the next five years. In 2004, a second 5-year plan was written, and it outlined the program's goals and plans through 2009 (Clark 2004).

Since 1991, Quabbin deer populations have been decreased substantially through the annual managed hunts, and the forest has responded tremendously. Regeneration surveys conducted during 2004 indicate that the number of tree stems/acre has increased from 910 in 1989 to 4,532 in 2004 (a 400% increase). Tree species diversity also continues to increase, and although white pine and black birch dominate the understory, more maple, oak, and hemlock trees are present.

Deer hunting on Quabbin Reservation is limited to a 4-day managed hunt, with access strictly controlled through a check-in/check-out procedure. Participating hunters are required to attend an orientation session every 6 years and follow specific rules and regulations to ensure hunter safety and protect water quality. Since 1991, over 4,000 deer have been harvested from Quabbin Reservation by approximately 19,000 hunters (**Table 57**). Since 1991, several administrative changes have been made to the hunt including allowing car scouting prior to the hunt, instituting a 5-block rotation, and defining antlerless deer killed at Quabbin as "bonus" (not counting towards the state-wide bag limits).

Table 57: Deer Harvest and Hunter Success Rate, 1991 to 2005

YEAR	TOTAL DEER	% FEMALE	% MALE	% A/L[1]	DEER/Mi^2 (killed)	# HUNTERS	HUNTER SUCCESS[2]	Mi^2 HUNTED
1991	575	60.3	39.7	71.8	40.9	855	67.3	14.1
1992	724	54.0	46.0	60.5	21.7	1971	36.7	33.4
1993	474	62.0	38.0	67.1	9.5	2168	21.9	49.7
1994	673	59.9	40.1	68.9	10.7	2118	31.6	63.1
1995	284	64.8	35.2	74.3	4.7	1508	18.8	60.9
1996	129	58.1	41.9	67.4	2.0	1213	10.6	63.1
1997	293	62.1	37.9	73.4	4.8	1207	24.3	63.1
1998	123	57.7	42.3	65.9	2.3	1099	11.2	55.8
1999	112	39.3	60.7	51.8	1.8	1192	9.4	63.1
2000	106	47.2	52.8	55.7	1.7	818	13.0	49.1
2001	101	51.5	48.5	58.4	1.9	855	11.8	52.0
2002	153	48.4	51.6	64.1	3.0	967	15.8	50.2
2003	306	69.0	31.0	83.7	6.9	938	32.6	44.2
2004	167	47.9	52.1	58.7	3.0	1259	13.3	55.8
2005	117	53.0	47.0	65.0	1.8	1071	10.9	49.0
Total	**4337**	**55.7**	**44.3**	**65.8**		**19,239**	**21.9**	**-**

[1] A/L: antlerless; females and young males with antlers less than 3 inches long.
[2] Hunter success is the number of deer taken per 100 hunters. Some hunters took more than one deer, so these figures slightly overestimate the proportion of successful hunters

5.4.4.5 Moose

5.4.4.5.1 General

Moose are North America's largest wild animal. An average adult moose weighs around 1,000 pounds and stands 6 feet at the shoulder. Moose and their ancestors originated in Siberia and made their way to North America across the Bering land bridge. At the time of European settlement, moose were distributed from Alaska, across Canada into the northern United States from North Dakota east to Pennsylvania and all of New England, including Massachusetts. Moose also extended down the Rocky Mountains in the West. Temperature was probably the limiting factor in the southern distribution of moose in North America. Winter stress typically occurs when temperatures exceed 23°F and summer stress when temperatures are >59°F (Franzmann and Schwartz 1997).

Moose were extirpated from Massachusetts by the early to mid-1800s (Peek and Morris 1998, Veccillio et al., 1993). A small number of moose escaped from a game preserve in Berskshire County around 1911 and may have persisted for several years (Veccillio et al., 1993). Most sightings during the next 50 years were probably northern vagrants. Since the late 1980s, the number of moose sightings has increased greatly (Peek and Morris 1998). In 1998, the state's moose population was estimated as at least 75 animals including cows with calves (Peek and Morris 1998). Current estimates of moose populations in Massachusetts are around 700 animals (MassWildlife pers. Comm.). Reasons for the increase in moose populations include the absence of predators, reversion of farms to forested areas, legal protection, increased wetlands from expanding beaver populations, and larger forest openings (Franzmann and Schwartz 1997).

Moose populations continue to expand in Massachusetts. Division land within the Quabbin watershed probably functions as a core habitat for moose populations given its large size and diversity of habitats. Moose populations in the state suffer relatively little natural or human caused mortality. Black bears are the only potential predator of moose and are limited to killing young calves. There are approximately 2000 black bears in Massachusetts, and most of them are located west of the Connecticut River. As a result, current bear populations are not capable of limiting moose populations. The main source of moose mortality is most likely from interactions with people. In 1997, 12 moose were killed on roads, 4 nuisance animals were destroyed, and 4 were immobilized and relocated (Peek and Morris 1998). It is likely that moose/vehicle collisions will continue to rise as moose populations expand. Because moose/car collisions are extremely dangerous for both humans and moose it has been suggested that moose are incompatible with an urbanized state such as Massachusetts, and the public's tolerance of moose is limited (Peek and Morris 1998, Veccillio et al., 1993).

5.4.4.5.2 Moose and Vegetation

Moose are primarily browsers and feed on the leaves, buds, and twigs of a variety of tree and shrub species. An adult moose can consume 40-60 pounds of browse daily (Snyder 2001). During the summer, moose spend time in lakes and ponds feeding on aquatic plants.

A good deal of work has been done assessing the impact of moose on boreal forest ecosystems (Danell et al., 1991, Edenius 1994, Angelstam et al., 2000, Connor et al., 2000, McLaren et al., 2000, Brandner et al., 1990, McInnes et al., 1992). There exists little if any information on the impact of moose in the southern portion of their range. While boreal ecosystems are relatively simple in terms of species diversity and structure, forests in Massachusetts are much more complex in both composition and processes. While information regarding moose in boreal ecosystems is important and insightful, it does not necessarily represent moose in mixed hardwood/softwood forests.

In Europe, moose were shown to have negative impacts on the quantity and quality of Scots pine (Angelstam et al., 2000). Moose density was found to be the contributing factor affecting the amount of moose related damage (Angelstam et al., 2000). A study in a Newfoundland park suggested that moose have changed species composition and influenced forest succession (Conner et al., 2000). Hunting has been prohibited in the park since 1974, and natural predation by black bears has not had an impact on the moose population (Conner et al., 2000). Several studies have examined the interaction of moose and Balsam fir, a preferred winter food of moose. In order to successfully regenerate Balsam fir in Newfoundland, McLaren et al., (2000) had to maintain high hunter harvest until trees were >3m in height. McLaren et al., (2000) concluded that since wolves were extirpated from Newfoundland, hunting has been the only option to reduce moose populations. McInnes et al., (1992) concluded that moose in the boreal forests of Michigan prevented saplings of preferred species from growing into the canopy. Further, it appeared that browsing by moose influenced the long-term structure and dynamics of the boreal forest ecosystem (McInnes et al., 1992).

Compared to the relatively simple ecosystem of the boreal forest, Massachusetts's forests are comprised of a diversity of hardwood and softwood species. The relative impact of moose on any particular species is unknown. However, there is substantial evidence linking overabundant deer populations in hardwood forests with negative environmental impacts (McShea et al., 1997). If moose populations continue to expand, the potential exists for moose to impact forest ecosystem structure and function. Localized browsing damage has already anecdotally been noted, particularly during winter weather when moose mobility becomes hampered and browse pressure becomes locally intense.

5.4.4.5.3 Monitoring Moose Populations

Because moose populations are expanding in Massachusetts and little is known about the potential impacts of moose on forest ecosystems, it is important to monitor moose populations over time to gather as much information as possible. The Division has taken an active role in a variety of moose research or moose related topics, including:

1. In April 2002, the Division began a moose monitoring program on the Ware River watershed (see **Estimating Relative Abundance of Moose on MDC Property: Results of the 2002 Ware River Pilot Project** report). Monitoring has continued yearly since 2002, and will continue into the future. The same monitoring program was initiated at Quabbin in 2003 on the Prescott Peninsula. However, staff shortages have prevented the study from being done since. Efforts will be made to restart the study during 2008.
2. The Division contributed $20,000 to funding a cooperative study of moose in Massachusetts. The study, being conducted by UMass and the USGS Massachusetts Cooperative Fish & Wildlife Research Unit, has several moose tagged with GPS collars to closely follow their movements.
3. An aerial infra-red survey of Quabbin Reservation was conducted during the spring of 2007 to identify deer and moose. The survey produced a known minimum number of animals during one point in time. While initial results were encouraging, time constraints prevented the contractor from adequately completing the survey. A new survey is scheduled for fall 2007.
4. Division staff have provided testimony at Senate sub-committee meetings discussing the potential impacts of moose on the landscape and encouraging legislators to modify existing laws to allow moose to become a regulated game species.
5. During the 2006 Quabbin deer hunt, hunters were given moose survey cards to report sightings. Hunters who saw moose during the hunt filled out the survey card and reported their sightings to Division biologists to record on a topographic map. Sightings were used to estimate minimum population estimates. Surveys will continue during future Quabbin hunts.

5.5 Management and Protection of Biological Diversity

Biodiversity can be defined as the diversity of life in all its forms and at all levels of organization (Hunter, 1999). This definition looks beyond simple species diversity to include genetic and ecosystem diversity as well. Setting management goals for maintaining biodiversity is inherently difficult for a variety of reasons. In most cases natural resource managers are responsible for managing biodiversity without a complete understanding of all the elements of biodiversity that may exist within the lands that they manage. For example, approximately 1.7 million species have been described globally, although estimates of the total number of species range from 10-100 million (Hunter, 1999). The local knowledge of species, habitat, and community dynamics is improving, but is still far from complete.

Incorporating the promotion of biodiversity in management activities requires management decisions to be made with a watershed, landscape, or larger regional perspective. Throughout the agency's tenure, DWSP management activities have incorporated specific practices that maintain or enhance biodiversity at the forest stand level (i.e., saving wildlife trees, buffering wetlands, protecting rare communities, etc.). In recent years, DWSP has made more deliberate efforts to further incorporate the landscape perspective in its efforts to support biological diversity. The "green" certification process (see sections 1.5.2 and 5.5.2.1.2) resulted in specific conditions for management requiring this larger-scale perspective in management. For example, certification conditions included the requirement to develop ecoregional plans as background guidance for local site plans (see section 1.5.3) and the recommendation that the state identify large and small areas permanently reserved from management, in order to allow the development of late seral forest conditions in significant blocks across the state (see sections 1.5.4 and 5.5.2.1).

Hunter (1999) describes only 2 real goals when planning for biodiversity: 1) Maintain the biodiversity of ecosystems that are in a reasonably natural condition and 2) Restore the biodiversity of ecosystems that have been degraded. DWSP's goals for biodiversity focus on maintaining or enhancing natural ecosystems across the watersheds. DWSP recognizes that its greatest contribution to regional and local biodiversity is protecting significant areas of land from development and maintaining those lands in forest or other natural cover. DWSP's primary management activity on these lands is creating small openings in the forest to stimulate regeneration and diversify species and age composition. These activities maintain forest cover while mimicking small-scale disturbances that occur naturally.

5.5.1 Biodiversity Mandate: Programmatic and Regulatory Framework

In 1973, Congress passed the Endangered Species Act to provide federal protection for 292 declining species, and began to legally define the national commitment to maintaining biodiversity in the process. The ESA specifically protected 27 plant and animal species in Massachusetts, and provided both the impetus and funding to restore popular species such as the Peregrine Falcon and the Bald Eagle in the state. Subsequent to the passage of the ESA, Massachusetts has added additional statewide legal protection for biodiversity. Both Chapter 131 (the Wetlands Protection Act) and Chapter 132 (the Forest Cutting Practices Act) require regulatory bodies to consider impacts on habitat and species during proposed development or management activities. In 1990, Massachusetts passed its own Endangered Species Act, providing protection currently for 424 plant and animal species. This act provides regulatory protection for significant habitats of the listed species, as well as direct protection for the species.

In recent years, the protection of biodiversity has become a high priority for Massachusetts state agencies. Massachusetts is a diverse environment that currently supports at least 15,000 visible (i.e., macroscopic) native species of plants and animals (including about 12,000 insects). MassWildlife (previously the Division of Fisheries and Wildlife) currently maintains the Natural Heritage and Endangered Species Program, the goal of which is to protect the state's native biological diversity. MassWildlife also recently launched the "Biodiversity Initiative," in order to coordinate two new programs that were created by the

1996 Open Space Bond Bill (Chapter 15, Acts of 1996). These programs include the Ecological Restoration Program and the Upland Habitat Management Program. The Ecological Restoration Program's major goal is to "focus future restoration action on the fundamental problems threatening biodiversity, including the restoration of natural processes and native community composition." To achieve this goal, the Ecological Restoration Program intends to follow the following strategies:

- Conserve species before they become rare by protecting their habitat.
- Restore natural processes that sustain biodiversity at key sites.
- Limit invasion by exotic or invasive species.
- Replicate natural processes, where they cannot be maintained or restored, at appropriate times, places, and in justifiable quantities.
- Consider species reintroduction only when species' requirements and causes of extirpation are sufficiently understood, and carefully consider the costs and benefits.

The Natural Heritage Program, in conjunction with the Massachusetts Chapter of The Nature Conservancy published "Our Irreplaceable Heritage: Protecting Biodiversity in Massachusetts" in 1998. This document outlines a Biodiversity Protection Strategy that includes the following:

- Encourage all conservation agencies, land trusts, municipalities, and not-for-profit conservation organizations to increase the importance given to and financial support for the conservation of uncommon and under protected components of biodiversity.
- Educate landowners about maintaining and restoring certain natural processes and minimizing disturbance.
- Aid land managers in implementing land management techniques that mimic natural processes where they cannot be maintained or restored.
- Strive to achieve an equitable distribution of biologically viable conservation lands at all topographic elevations and across all ecoregions.
- Take action to conserve natural communities and species that have experienced tremendous loss or are under considerable threat.
- Focus attention on natural communities and common or rare species that are underprotected.

The April 2000 "The State of Our Environment" from the Executive Office of Environmental Affairs (EOEA, now the Executive Office of Energy and Environmental Affairs, EOEEA), acknowledges the link between human needs and healthy, thriving natural communities. EOEEA identifies loss of habitat through development and invasive species as the two most distinct threats to maintaining natural diversity in Massachusetts, and further commits to preserving biodiversity through the identification and protection of critical habitats and the creation of bioreserves that include central cores of public land.

As stated in Section 4.5, DWSP's principal goals for maintaining biodiversity on its Quabbin holdings are to retain most of these lands in a forested condition, to identify and provide habitat for the protection of uncommon and rare flora and fauna, and to eliminate and prevent the spread of non-native invasive

species. DWSP also seeks to provide the range of seral stages from early successional habitat through unmanaged mature forest across its total holdings.

5.5.2 Massachusetts Biodiversity Objectives and Accomplishments: 1995-2007

The maintenance of biological diversity across the Commonwealth of Massachusetts has been a priority among state agencies for many decades, although the term "biodiversity" has been popularized only since the mid-1980s. In 1988, E.O. Wilson edited and published Biodiversity, a National Academy Press publication, and the term has been in popular use since that time. Preserving our "natural heritage" carries similar objectives as the conservation of biological diversity and programs devoted to natural heritage have been developed in every state in the U.S., including the Natural Heritage and Endangered Species Program (NHESP) in Massachusetts, a component of the Division of Fisheries and Wildlife. The Massachusetts NHESP, in conjunction with the Executive Office of Environmental Affairs and the state land agencies, has been at the forefront in developing programs to support the conservation of biodiversity.

5.5.2.1 Statewide Biodiversity Initiatives

5.5.2.1.1 BioMap

The BioMap was an initiative of the EOEEA to utilize existing and new databases of rare plants, animals, and natural communities collected since 1980 to produce a guide for land conservation efforts in the state that would more efficiently support and protection existing and potential sources of biodiversity. The BioMap report, published in 2001, provides the methods used in the assessment of 7,000 site-specific records within 13 ecoregions in Massachusetts which generated priority areas for conservation efforts. Within each ecoregion, "core habitat" is identified as well as areas within that core that are currently protected versus unprotected. A full text of the BioMap as well as technical guides to the process are available through NHESP and/or online at http://www.mass.gov/dfwele/dfw/nhesp/nhbiomap.htm .

5.5.2.1.2 Green Certification

At the beginning of the previous management period for the Quabbin Reservoir watershed, the Division sought "green certification" from the international Forest Stewardship Council, through the FSC-approved SmartWood program of assessment. The 1997 certification of Quabbin Reservoir watershed forestry practices was the first third-party, "green" certification of public lands management in North America. As the Quabbin certification approached its five-year renewal date, the Executive Office of Environmental Affairs (EOEA, now EOEEA) decided to pursue a broader certification audit. On May 11, 2004, *all* state forest lands in Massachusetts became "green" certified.

Certification provides third-party review and auditing of forest management practices for the long-term sustainability of their relationship to the environment and to the regional human economy. The Massachusetts state lands certification was granted by Scientific Certification Systems, an independent, third-party certification body accredited by FSC. Certified lands in Massachusetts are managed by different agencies of the EOEEA, including the Division of State Parks and Recreation (285,000 acres), the Division of Fisheries and Wildlife (110,000 acres), and the Division of Water Supply Protection (104,000 acres). With this certification, Massachusetts becomes the first state in which multiple forest management agencies have joined forces to earn certification of all of the publicly managed state forestland. Certification is an endorsement, but conditions for improvements in management practices must be attained within a five-year period for this endorsement to remain current and valid. The full MA certification report, including the details of these conditions is available online, at www.mass.gov/envir/forest/default.htm.

5.5.2.1.3 EOEEA Reserve Initiative

As a result of the green certification process, EOEEA also initiated an effort to identify large areas across the state land holdings that would be permanently set aside from commercial timber harvesting in order to allow the development of habitat conditions that may not develop under active management. These large reserves were identified through a scientific process worked out in conjunction with science staff from The Nature Conservancy and intend to provide conservation of habitat conditions determined to be high priorities at the landscape scale of analysis. Nine reserves totaling in excess of 50,000 acres were proposed by EOEEA in 2005 and adopted in 2006. A full description of the process and these proposed reserves is available online at www.mass.gov/envir/forest/pdf/whatare_forestreserves.pdf.

5.5.2.2 Quabbin Biodiversity Initiatives

5.5.2.2.1 Identification of Rare, Uncommon, and Exemplary Communities

The Quabbin watershed harbors a wide array of unique natural communities. Some of the communities are rare on a regional or global level. In response to a recommendation by the FSC forest certification auditor that the biological diversity at Quabbin should be better characterized, the University of Massachusetts Department of Natural Resources Conservation, under the primary direction of Associate Professor Kevin McGarigal, from 1997 to 2000, assessed the watershed for rare, uncommon, and exemplary natural communities. In a September, 2000 report entitled, *Rare, Uncommon, and Exemplary Natural Communities of Quabbin Watershed"*, the purpose of this study is described: "to identify, classify, and describe the rare, unique, and exemplary natural communities in the Quabbin watershed area of Massachusetts and to provide recommendations for their management". The report identifies 22 rare communities in the Quabbin watershed and describes these in detail and is available through Natural Resources staff at Quabbin.

5.5.2.2.2 Protection of Rare Species

The Division provides extensive protection for known populations of rare, endangered, or uncommon species, primarily through protection of their habitats. Division staff record new occurrences as they are discovered, and track changes in existing populations. The Division works extensively with the DFW Natural Heritage and Endangered Species Program to protect these species, and through a joint collaboration between DCR and NHESP, recently helped to produce updated Forestry Conservation Management Practices for specific species that may be encountered during harvesting operations.

The following were among the protection efforts initiated by the Division during the previous management period:

1. Identification and mapping of populations of rare plant species, first through a two-year contract with the University of Massachusetts Biology Department, and later through annual visits by professional botanists to survey habitats predicted to contain rare species. From 1995 to the present, at least 15 new populations of rare or endangered species were identified through this survey work (see section 2.6.2.2), including a 2007 discovery of *Asclepias purpurascens L.*, the threatened Purple Milkweed.
2. On at least two of the sites on which populations of rare plant species were identified, manual removal of invasive plant species threatening these populations was performed by Natural Resources staff.
3. New Wildlife Conservation Management Practices (WCMPs) for the protection of habitats and rare species during harvesting operations were developed with NHESP for Blanding's turtle, eastern box turtle, wood turtle, spotted turtle, four-toed salamander, mole salamanders, and common loon. Discussions also focused on identifying critical habitat conditions surrounding vernal pools, and forestry practices to maintain these.

5.5.3 Areas with Special Management Restrictions and Small Reserves

The 1972 *Quabbin Reservoir Watershed Land Management Plan* delineated areas on which conventional forest management practices were either impractical or otherwise undesirable. That plan included 3,360 acres in "Aesthetic Areas" and 3,200 acres of "Protection Areas", which included islands, rock quarries, caves, rock outcrops, hill top views, cellar holes, mill sites, exceptional forests or individual trees, and areas that have been undisturbed for the past 100-150 years. The "Protection Areas" also included 1,350 acres in the Cadwell Creek watershed, a control area for a watershed study done by the University of Massachusetts. While the Division had not planned cutting in the "Protection Areas", commercial forest management in the "Aesthetic Areas" was allowed if special logging techniques were used. The plan also included 1,440 acres in "Wildlife Wetland Areas" (chiefly beaver flowages), where no cutting was planned.

In the 1986 *Quabbin Forest and Wildlife Management Plan*, 7,600 acres were designated in the "Protection Zone". This zone included steep, rocky, or extremely wet sites; exceptional, rare, or endangered plant communities, or wildlife habitat; and significant cultural resource sites. No forest management was permitted in this zone.

This Section updates the concept of areas where special management restrictions apply. As the Division continues to refine its analysis of the watershed protection provided by the lands under its control, some refinements in the restrictions have been made. For instance, efforts to maintain an understory (for the reasons cited throughout the plan) seem even more critical in riparian zones than in areas that are distant from tributaries or the shoreline. While riparian areas have traditionally been untreated, understory maintenance will be a priority for this decade, and will include such practices as planting, single tree selection harvesting, and non-harvest silviculture to stimulate understory growth.

Table 58 lists the areas with special management restrictions as they stand currently. The recent Forest Stewardship Council re-certification of Quabbin's forest management practices, provided by Scientific Certification Systems, acknowledged the long-standing identification and treatment of these areas by the Division as meeting the certification criteria for the designation of "ecosystem reserves". Specifically, the certification report states:

> [DCR] has submitted adequate information to determine that they have reserved a substantial portion of their ownership (>15%) as natural areas or unmanaged lands. Furthermore, the silvicultural strategy employed on [DCR] lands assures that old forest conditions will be encouraged within managed areas of the forest. This agency is protecting a substantial amount of their ownership, and they have done extensive inventories for rare species and communities on their ownership. (SCS 2004)

Included in the lands in **Table 58** are two major categories:

- Areas with uncommon, rare, or potentially rare resources.
- Areas where commercial forest management is impractical.

The first category includes areas such as uncommon forest communities, habitats containing rare, endangered, or threatened plant or animal species, and historic/prehistoric sites. Examples of these areas include pitch pine/scrub oak communities, diverse or unique regions designated as Natural Areas, and cellar holes and Native American encampments and work sites. The delineation of each area may also designate an appropriate buffer zone around the resource.

The second category includes commonly occurring but fragile areas such as bogs, forested wetlands, marshes, wet meadows, vernal pools, areas with fragile wetland soils, and slopes greater than 30%. There may be rare plants, animals, or communities within these sites as well, and overlap of the two categories

of restrictions is not uncommon. For example, steep talus slopes are generally impractical to operate with timber harvesting equipment and often harbor rare or uncommon plants as well.

Approximately 10,000 acres of DWSP lands at Quabbin were classified in the 1995-2004 Land Management Plan as "Areas with Special Management Restrictions". These areas include large blocks of land such as the 3,716 acres of reservoir islands and two blocks in excess of 1,000 acres each in Quabbin Park and adjacent to Pottapaug Pond. All identified wetlands and steep slopes are included, some of which are contiguous areas of several hundred acres (e.g., the steep Pelham shoreline, or the wetlands along the East Branch of Fever Brook). In addition, many small areas have been included, representing sensitive resources and buffers around historic and rare wildlife habitat areas. For example, Division and University of Massachusetts staffs have mapped, from aerial photos, more than 500 potentially viable vernal pools across the Quabbin watershed.

In addition to these previously designated lands, the Division has been gradually mapping areas that are impractical to manage for a combination of reasons. For example, some potentially manageable land is enclosed by wetlands or adjacent rare species habitat in such a way that the land will not be managed. These lands will be excluded from the total acreage considered to be under active forest management. Based on a similar approach on the Ware River watershed, it is expected that once the mapping process has been completed, the acreage that is identified as reserved from active management will total approximately 25-30% of the total DWSP holding at Quabbin. Therefore, approximately 15,000 to 18,000 acres on this watershed will grow and develop without timber harvesting. There may still be efforts to manage such influences as invasive species, herbivore populations, and fire on these properties, but active commercial silviculture is not planned for these areas.

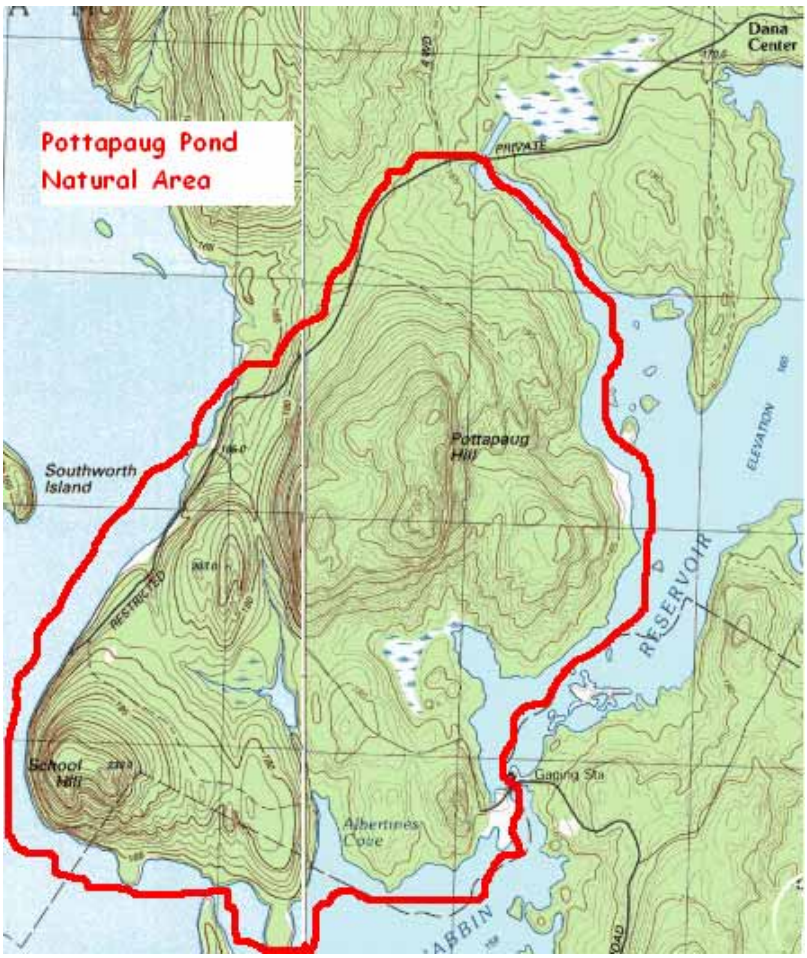
Table 58: Areas with Special Management Restrictions within the Quabbin Reservoir Watershed

Area	Acres	Restrictions/Practices
Islands	3,674	No management
Steep slopes	1,712	No management
Wetlands	2,272	No management except limited beaver control (see beaver policy, Section 4.4.4.1)
Rare and endangered species habitats	NA	Subject to restrictions upon advice of Natural Heritage and Endangered Species Program
Quabbin Park (western portions) acres	1,058	Limited management including tree planting, non-commercial regeneration cuts, and roadside salvage cutting
Pottapaug Natural Area	1,183	Restricted by designation as a Natural Area, in 1991, no commercial management.
Areas where access is precluded by physical or regulatory barriers	Mapping in progress	No active commercial management; control of herbivores, invasive species, fire may occur
Areas of Historic, Cultural, or Natural Significance	NA	Varies from no management to selective restoration and maintenance

Areas that have been set aside for the reasons mentioned above also can function, on a long- or short-term basis, as areas from which background measurements can be taken for comparison to areas that are directly under management. The Division will retain this function, and will regularly reevaluate the sufficiency of current "restricted" areas for establishing background information.

GIS analysis has provided some preliminary information on this topic. For instance, of the 12 common forest types occurring on the Quabbin Continuous Forest Inventory plots, six are also represented on CFI plots that fall within the "restricted" areas (most of the "missing" types are generally uncommon, such as red spruce, larch, or pitch pine.) Each of the five Division soil types (see Section 2.2.6.) is well-represented within the "restricted" areas. The Pottapaug Natural Area (**Figure 23**) was added to this category to address the public interest in a block of accessible forest that was allowed to grow and change without silvicultural intervention. The area was chosen because it offered a wide variety of forest types and wildlife habitats but was hydrologically removed from the Shaft 12 intake and sheltered from typical, south-easterly hurricane winds. The details of long-term management of this area, including fire and invasive species response, are being developed (e.g., the decision to let a wildfire burn rests in the hands of the fire chief of the town, not with the Division).

Figure 23: Pottapaug Natural Area



5.5.4 Management for Special Conditions

5.5.4.1 Primary Forests

5.5.4.1.1 Definition and Significance

Primary Forest or "primitive woodlands" are areas that have always been in a forest condition or cover. These lands were not cleared for crops or pasture, and instead managed for forest products, such as timber for barns and houses and for firewood. The location of primary forest comes from crude maps provided by the Harvard Forest that were made for tax purposes by town governments in Massachusetts in 1830, at the height of agricultural clearing. The working assumption is that because these woodlands had not been cleared by the height of the land clearing period, they likely have been woodlands throughout history. The locations of Quabbin's Primary Forest were determined from these maps. These forests are usually located in the uplands, on steep and/or on rocky ledge soils or wetlands unsuitable for even pasture. Cultural features such as stone and wire fences are absent and often late successional species such as hemlock, beech and tupelo are present. Sometimes the maps were found to be incorrect, as to the extent of the primary forest, because field checks found stone fences and pasture type trees even on steep and rough land with stony soils and exposed ledge. In a few cases primary forest were located on mostly level uplands and suitable for quality pasture, but for some reason stayed in forest. Part of the significance of primary forest is that many organisms from the original forest may still be present and may be important in determining long-term sustainability of forest ecosystem integrity.

5.5.4.1.2 Management Practices in Primary Forests

Since most of the primary forest at Quabbin is either on steep slopes or wetlands or on sites of very low productivity, it has not been and likely will not be actively managed. Primary forest located on productive and accessible areas will be managed using multi-aged silvicultural methods. The proposed management would allow for older age classes to occupy more then 1/3 of the area. Cutting cycles would vary from 30-50 years and require 60-100 years to develop multiple age classes where only one now exists. At the stand level this management would be designed to promote and maintain structural elements, similar to those found in old growth stands. Structural targets are 12 or more trees/acre >20" DBH and dead snags and live cavity targets are 2 trees/acre > 12" DBH, 3 trees/acre >15" DBH, 1 tree/acre > 18" DBH and 1 tree/acre > 20" DBH. Primary forest occupies approximately 10-15% of the overall forest.

5.5.4.2 Late Seral Forest Conditions

5.5.4.2.1 Value of Late Seral Forest Conditions

The late seral stands discussed here are often the second forest stand to occupy the site since the land was abandoned for agricultural purposes such as pasture or tillage. These stands are often on productive soils and with species well suited to the site. Most of these stands regenerated between the Civil War and World War I. They are not of great age but are of large diameter, exceptionally tall, and of high quality. Their location varies from very accessible to remote and consequently spread across the landscape. Their importance is derived from both their scattered presence on the land and their potential to provide old growth attributes at an early age. They are often bordered by primary forest or stone walls and agricultural border trees of great size, that often have large cavities. Unlike primary forest, which tends to be on less productive sites, these late seral stands are on highly productive sites and consequently of high stocking (density). They came about during a time with few or no large herbivores or invasive species, diseases and insects. Air pollution was minimal during most of their development. The plant community and the processes that assist its growth and development were intact. These exceptional conditions for tree and stand development may be impossible to duplicate in the future, but the Division will try to take advantage of the exceptionally good conditions afforded by these stands.

5.5.4.2.2 Management Practices to Produce and Sustain Late Seral Forest Conditions

Management of these stands will promote regeneration of similar species, maintain vigor of the overstory and allow for structural conditions similar to old growth. The selection system would be used employing single tree and small group removals and conducted every 30-50 years. Structural targets would be 17 trees/acre > 20" DBH and dead snag and live cavity tree targets would be 3 trees/acre > 14" DBH, 2 trees/acre > 16" DBH, 1 tree/acre > 20" DBH, and 1 tree/acre > 24" DBH. Late seral stands would occupy up to 15% of the forest.

5.5.4.3 Early Successional Forest Habitat

5.5.4.3.1 Importance of Early Successional Forest Habitat

Broad changes in land use have dramatically impacted the number, type, and extent of open lands within the watershed. Early successional habitat was a major component in the landscape prior to European settlement. Evidence suggests that grasslands existed in the Northeast before Europeans arrived, and grassland birds have been a component of avian diversity for a long time (Dettmers and Rosenberg 2000). Beaver activity, wildfires, windstorms, and fires set by Native Americans generated early successional habitat. By the 1800s grasslands were even more abundant in the northeast as agricultural land dominated

the landscape. Since the mid-1800s, the amount of grasslands and open fields has decreased dramatically, causing a similar decrease in many species of plants and animals that depend on open habitat. As farms were abandoned, the open fields and meadows were left undisturbed. Without frequent disturbance such as mowing, burning, or grazing, grasslands gradually revert back to forest. Some grassland species, such as the loggerhead shrike and regal fritillary butterfly, have been extirpated from Massachusetts as their preferred habitat has declined below a minimum threshold.

Recent population trends for grassland dependent species show disturbing declines. Bobolinks and grasshopper sparrows have declined 38 and 69 percent, respectively in the last 25 years. Partners in Flight, a national conservation organization, has identified Neotropical migratory bird species of concern in Massachusetts. These species have a high perceived vulnerability (they may or may not be state or federally listed) and are critical to maintaining avifauna diversity in the state. Priority species include Henslow's sparrows, upland sandpipers, grasshopper sparrows, and bobolinks. These species are all associated with grassland habitat. As farmland continues to be abandoned or converted to house lots, the amount of viable open land continues to shrink. The remaining grasslands, particularly large (>100 acres) or clustered fields, are increasingly vital to a variety of wildlife. Eastern meadowlarks, savanna sparrows, eastern bluebirds, and bobolinks use hayfields, meadows, or pastures to forage and raise young. During the fall and winter, fields provide food for migrating sparrows, warblers, larks, and snow buntings. Raptors such as northern harriers, short-eared owls, and American kestrels hunt in fields for small mammals (meadow voles, meadow jumping mice) and insects. White-tailed deer often graze in fields, and foxes will hunt fields for small mammals or rabbits. Finally, butterflies like the monarch, tiger swallowtail, and various fritillaries feed on nectar of grassland wildflowers.

Early successional forested habitat is also in decline in Massachusetts. Evidence suggests that early successional forested habitat was present in sufficient amounts and distributed well enough across the landscape to support long-term populations of early successional birds in the Northeast prior to either European or Native American intervention (Dettmers and Rosenberg 2000). Fire, major weather events, or beaver activity maintained or generated these habitats across the landscape. European and Native American populations increased the amount of early successional habitat in the region. By the mid 1800s, forest cover in New England had dropped from >90% to <50% (Dettmers and Rosenberg 2000). As farms were abandoned during the late 1800s large amounts of early successional habitat became available. Over time these large areas of early successional habitat grew beyond the early seral stages used by early successional species. A survey conducted in 1998 in Massachusetts concluded that only 4 percent of all available timberland was in a seedling-sapling (early-successional) stage (Trani et al., 2001).

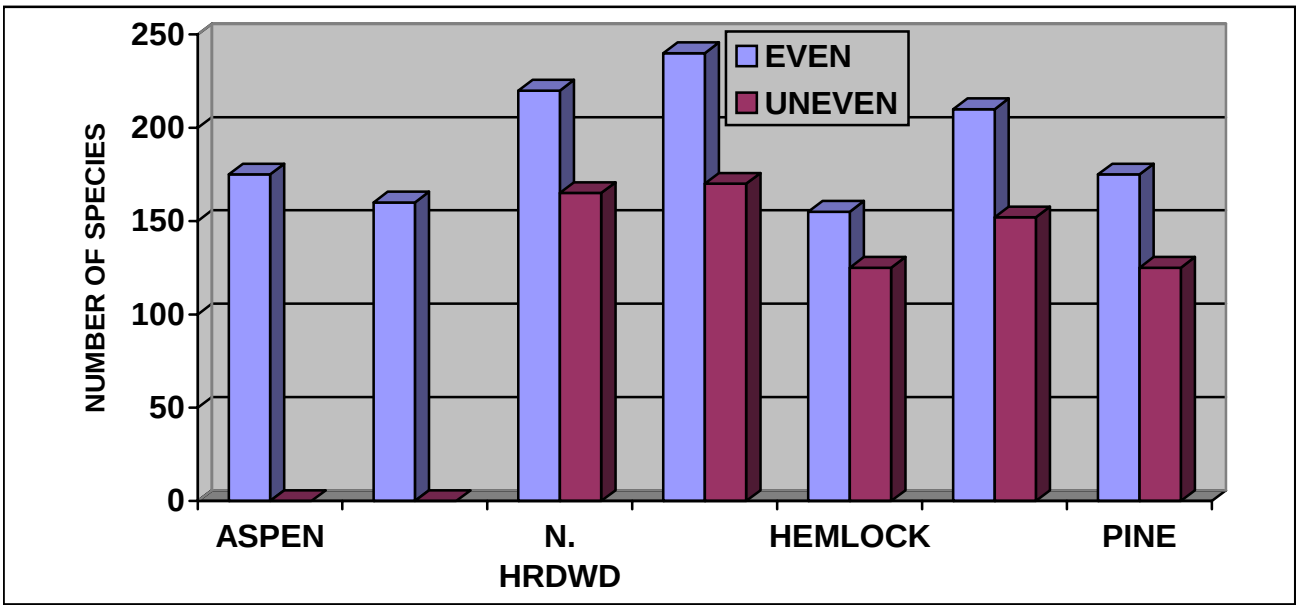
Species dependent on these early successional habitats have been declining since the 1950s as the amount of available habitat continues to shrink (Scanlon 2000). The Partners in Flight "species of concern" list highlights species associated with early successional forested habitat (i.e., blue-winged warbler, Eastern towhee, and prairie warbler). In addition, New England cottontails, bobcat, woodcock, and northern bobwhite have all experienced declines and are dependent on early successional habitat (Hunter et al., 2001, Dessecker and McAuley 2001, Litvaitis 2001). Providing habitat for early successional species involves considerations in both space and time. Early successional habitats are temporary and only support wildlife for 8-15 years. To remain viable, these habitats need to be set back on a regular basis or new areas of early successional habitat need to be created nearby to replace them.

5.5.4.3.2 Management Practices to Maintain Early Successional Forest Habitat

Even-aged forest management is the primary technique used to produce early successional forest stands. This type of silviculture provides the opportunity to regenerate shade-intolerant species such as aspen and birch. The resulting habitat provides distinct foraging and shelter features that are not usually available when uneven-aged management is used (DeGraaf et al., 1992). In addition, even-aged management

appears to have little effect on mature forest species (Thompson and DeGraaf 2001). Even-aged management provides habitat for up to 26% more species than uneven-aged management in similar cover types (DeGraaf et al., 1992) (**Figure24**). Payne and Bryant (1994) state that even-aged management tends to support more wildlife species than uneven-aged management does in northern hardwoods, hemlock, oak-pine, and pine forests of the northeast. Because the current level of tree harvesting within the state is relatively light, widely dispersed, and generally does not provide substantial early-seral habitat, the Division will try to incorporate management techniques geared towards creating a limited amount of this type of habitat, to the extent that this is compatible with water supply protection. In the end, utilizing a range or combination of silvicultural treatments, rather than strict adherence to one, should eventually result in increased use by a wider variety of wildlife species (DeGraaf et al., 1992).

Figure 24: Potential Number of Wildlife Species by Silvicultural System and Cover-type Groups



Wildlife species defined as total number of amphibians, reptiles, birds and mammals using each cover type taken from DeGraaf et al., 1992.
Even-aged: forests containing regeneration, sapling-pole, saw timber, and large saw timber stands of 5 acres or larger.
Uneven-aged: essentially continuous forest canopies and intermixed size and age classes produced by single-tree selection.

Uneven-aged management techniques will be the primary silvicultural approach across the watershed.. For this 10-year management period, the Division's goal for the creation and maintenance of early successional forested and non-forested habitat will be approximately 1% of the manageable land.

Although "clear-cuts" are often associated with even-aged management, there are a variety of even-aged techniques that can be used to accomplish particular management goals. Typically 10-20% of the overstory will be retained in clusters of 5-10 trees scattered across the stand, where creation of these habitats is the objective. An average of 2-3 clusters per acre will be retained. These occasional clumps of trees are an attempt to mimic natural disturbances. Major catastrophic events typically don't completely remove the overstory in a given area, but instead create a patchy effect on the landscape as some trees survive the event. In addition, preserving clumps of trees allows the Division to selectively save valuable mast, den, and nest trees.

In order to create conditions favorable for early successional species, forest openings need to be large enough and placed appropriately to provide enough habitat to sustain viable animal populations over time. The small group openings or single-tree selection that is conducted on a majority of Division land does not provide habitat for species dependent on early successional forest. To the extent that maintaining this habitat is an objective of the Division, larger openings would need to be created on selected areas of the

watershed. Ideally, natural land forms would select the boundaries of these openings and actual acreage would simply work itself out. From a biodiversity perspective bigger tends to be better because larger habitats can more viably sustain animal populations over time. Forest openings of various sizes would be carefully placed within the watershed to ensure adequate water quality protection. Topography, distance to tributaries, soils, stand vigor, and distance to human interface would be considered when planning early successional habitat management. Introducing a limited amount of this type of management provides an opportunity for further study to determine the short and long-term effects of even-aged management on nutrient cycles and water quality parameters.

The Division recognizes the regional importance of these open lands to the diversity of wildlife within the state. Unfortunately, land managers can't rely on nature or natural disturbances to provide this type of habitat. The large amount of land that has been lost to development, coupled with the loss of species and abundance of exotic, invasive species have all combined to alter natural processes. The maintenance of these types of habitats requires active management. Although the Division will continue to manage a majority of its property as a multi-aged, multi-species forest, on particular areas where open habitat exists, or could exist, the Division will manage to maintain or enhance early successional communities.

5.5.4.4 Early Successional Non-Forest Habitat Management Practices

5.5.4.4.1 Field Prioritization

The Division owns a variety of open lands. In most cases, these are lands the Division has traditionally managed in an open condition. Analysis of the distribution, size, and juxtaposition of open lands within the watershed highlights the need for prioritization. Fields will be prioritized based on their size, distance to flowing water, relative isolation, and juxtaposition with other open fields. In general, very small (<2 acres), isolated fields will be abandoned and allowed to naturally regenerate to forest cover. In addition, those fields (or portions of fields) that border reservoir tributaries will also be abandoned and trees allowed to grow. This will provide an adequate forest buffer around flowing streams. Larger fields (>5 acres) that are isolated will be maintained in open condition through various management practices. Large (>20 acres) fields situated near (< 1 mile) or next to other fields will be given top management priority, because these areas offer the most potential for wildlife diversity. Large clusters of open habitat may actually act as one unit, providing habitat for species (northern harrier, upland sandpiper) that require large tracts of open land. These areas will be maintained or enhanced using a variety of management techniques in order to optimize the available habitat.

Following prioritization, those fields not abandoned will receive management to either maintain them in open habitat or to enhance the existing conditions. Management activities will be done by Division personnel, or through a service contract. In all cases, wildlife considerations will be incorporated into the proposed management activities.

The quality of Division grasslands is variable. Encroaching exotic invasive plants are invading some fields. These plants typically crowd out native species and degrade the quality of the existing habitat. Most invasive plants are extremely vigorous and hardy and can be difficult to control. Removal and control of these species is critical to the maintenance of this grassland habitat. Multiflora rose, autumn olive, honeysuckle, and buckthorns have all been found in Division grasslands. Control of invasive plants is addressed in Section 5.5.5.

5.5.4.4.2 Periodic Maintenance Practices for Non-forested Upland Habitat

The Division owns and maintains approximately 60 acres of manicured lawn, located primarily at the administration complex and adjacent to the radio observatory on Prescott Peninsula. These lawns are mowed regularly during the growing season. The Division also owns approximately 165 acres of fields

throughout the watershed. These fields are comprised of a variety of grasses and forbs, and on these fields, wildlife habitat management is an important secondary objective. These fields still require active management in order to maintain them in a grassland condition. However, there are more opportunities to apply various management techniques to enhance the existing habitat.

The following management guidelines for mowing on lands not used for hay production will be followed:

- Limit mowing to every one to three years; this regimen will inhibit woody vegetation while allowing late-blooming wildflowers to develop.
- Mowing should occur after August 1.
- Mower height should be a minimum of 8-10 inches off the ground to provide habitat for small mammals.
- Manage adjacent fields as one unit; multiple contiguous fields should be managed through rotational mowing to provide a diversity of grassland types.

The Division owns several large contiguous grasslands that are potential candidates for other management activities. In addition, some smaller grasslands may also be suited to disturbances other than mowing. Burning grasslands can reduce buildup of dead vegetation, prevent the spread of woody vegetation, release nutrients into the soil, and rejuvenate plant growth. However, burning an area can eliminate some butterflies and moths and the newly burned area may be avoided by some bird species. When feasible and practical, fire management can be a benefit to grassland bird populations and other wildlife usually within a year or two of the burn. If and when the Division conducts fire management, the following guidelines will be followed:

- Burns should be conducted in early spring (mid-March to the end of April) after snowmelt but before bird nesting. Appropriate weather conditions should be considered.
- Grasslands should be burned once every 3-4 years, and if possible, an unburned, adjacent field should be available for nesting birds during the burn year.
- On larger grasslands, only a portion of the area should be burned, if possible, in any given year. Staggering burns allows for the development and availability of a variety of habitat conditions. Not more than 30% of habitat should be burned during any year.

5.5.5 Invasive Plants Management

5.5.5.1 Definitions

"Invasive" plants fall into at least two categories – native or non-native species. Most of the difficulties associated with invasive plants involve plants that are non-native. This is true in part because these non-native "aliens" have been transported out of the ecosystem in which they evolved, and may have escaped specific population-controlling insects and diseases in the process. It is important to point out that not all non-native plants are invasive. Most have been intentionally introduced into agricultural or horticultural environments, and many are unable to reproduce outside of these intensively managed environments. There are, unfortunately, hundreds of others that were introduced either deliberately or accidentally to natural settings and have managed to aggressively force out native plants, raising serious biodiversity issues, and potential threats to water quality protection.

It has taken time for these issues to become apparent. Some of the invasive plant problems on DWSP properties are the result of deliberate plantings of species that effectively addressed other concerns (for instance, planting autumn olive to improve wildlife habitat), but then became invasive. Other invasive species are escapees from landscaping that predates DWSP's acquisition of reservoir properties, including Japanese barberry, common barberry, Japanese knotweed, the buckthorns, Asiatic privets, honeysuckles, and purple loosestrife. In all cases, a plant's "invasiveness" is composed of several defining qualities:

- The plant grows and matures rapidly in abundantly available habitats.
- The plant is capable of producing vast quantities of seed that is easily dispersed by animals, and often can also reproduce vegetatively.
- There are no diseases or pests effectively controlling its reproduction and spread (which generally means there are no close relatives in the habitats it invades).
- The plant does not require intensive management to thrive.

5.5.5.1.1 Federal and Massachusetts Definitions

In February of 1999, President Clinton signed Executive Order 13112, to "prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause"(see: www.invasivespecies.gov/council/nmp.shtml). EO 13112 created a federal Invasive Species Council to "recommend plans and actions at local, tribal, State, regional, and ecosystem-based levels" to address prevention and control of invasives. The first edition of a National Invasive Species Management Plan from this Council was produced in January of 2001, serving as a blueprint for invasive species actions. This plan provides both additional mandate and an overview of the costs and agency responsibilities to begin to gain control over invasives. More recently, the Massachusetts Invasive Plants Working Group produced a methodically developed list of invasive and potentially invasive plants in the Commonwealth, through cooperation among biologists, government staff, non-profits, nurseries, and landscape organizations (see: massnrc.org/MIPAG/index.htm). Strategic recommendations for managing invasive plants in Massachusetts have also been developed by the same group, and are posted on the New England Wild Flower Society's website, at: www.newfs.org/conserve/invasive.htm#strat1. Following the creation of the list of invasive and potentially invasive plants in Massachusetts, the Massachusetts Department of Agricultural Resources, Division of Regulatory and Consumer Services filed legislation to phase these species out of commercial production and use. This legislation passed and became effective on January 1, 2006, effectively phasing out the sale and importation of 140 plant species (see: www.mass.gov/agr/farmproducts/Prohibited_Plant_Index2.htm).

5.5.5.2 Problems Associated with Invasive Plants

The EOEA report "The State of Our Environment" (April, 2000) states that "the two biggest threats to biodiversity in Massachusetts are the destruction and fragmentation of wildlife habitats and the introduction of invasive non-native species." The Nature Conservancy has reported that 42% of the declines of threatened or endangered species in the US are partly or wholly due to the effects of invasive species. Some of these threats are subtle. For instance, when the declining West Virginia White butterfly lays its eggs on the invasive garlic mustard instead of on the usual native mustards, its eggs fail to develop. Other threats are more obvious; for instance, purple loosestrife currently covers an estimated 500,000 acres in northern US and southern Canada, displacing native food sources and threatening to prevent successful nesting in 90% of the wetlands used by breeding waterfowl along the Atlantic and Mississippi flyways. Impacts from invasives on the soil and its faunal community have also been

documented. There is evidence that a Chinese tallow tree is altering nutrient cycling where it invades, causing a decline in the native soil invertebrates as a consequence.

Beyond issues of biodiversity conservation, resilient plant communities are important to watershed management for controlling the erosion of soil and nutrients throughout the range of natural disturbances (e.g., droughts, insect outbreaks, fire, wind, heavy snow and ice). Resilience is dependent upon species and size diversity in the plant community, because disturbances are frequently species and/or size specific. When plants become aggressively invasive, replacing the diverse native flora with monocultures, they increase the susceptibility of the plant community to disturbances. The prevention of forest regeneration by certain aggressive invasives has become a problem on some areas of the watersheds. Around the Quabbin Reservoir, Japanese barberry that was planted on historic home sites has taken advantage of high deer populations (which do not feed on barberry) to colonize and monopolize the understories of significant forest areas. At the Wachusett Reservoir, autumn olive has aggressively occupied open fields, delaying or precluding their return to forest cover. Invasives are often more effective than natives in colonizing disturbed areas, and may overrun young trees that do become established. **Table 59** lists the invasive plants that are present surrounding the Quabbin Reservoir.

Invasion by Japanese barberry on rich, mesic (moist) site

Table 59: Invasive Plants Present on the Quabbin Reservoir Watershed

Common name	Latin name	Habitat
Black locust	*Robinia pseudoacacia*	Edge of forest/field
Norway maple	*Acer plantanoides*	Forest
Oriental bittersweet	*Celastrus orbiculata*	Forest
Japanese barberry	*Berberis thunbergii*	Forest
Common barberry	*Berberis vulgaris*	Forest
Glossy buckthorn	*Frangula alnus*	Forest
Common buckthorn	*Rhamnus cathartica*	Forest
Honeysuckles	*Lonicera sp.*	Open areas
Autumn olive	*Elaeagnus umbellata*	Open areas
Russian olive	*Elaeagnus augustifolia*	Open areas
Multiflora rose	*Rosa multiflora*	Open areas and edges
Goutweed	*Aegopodium podagraria*	Floodplains, riparian areas
Japanese knotweed	*Polygonum cuspidatum*	Riverbanks, wet edges
Purple loosestrife	*Lythrum salicaria*	Wetlands
Garlic mustard	*Alliaria petiolata*	Floodplains, disturbed woodlands, roadsides
Phragmites (common reed)	*Phragmites australis*	Wetlands
Winged euonymus	*Euonymus alata*	Open woods, fields, edge

5.5.5.3 Control and Management Options

All of the features that make a plant invasive also frustrate efforts to control and reverse its expansion. Seed production is generally prolific, and many invasives also reproduce vegetatively. General control requires the removal or killing of mature plants, but also requires that these removals be timed in such a way that they do not result in further reproduction and spread of the plant. Controls are either mechanical

or chemical. Mechanical controls include hand-pulling, girdling or mowing, mulching, tilling, and the use of heat. Chemical control is often more efficient and effective, but carries stronger risks of collateral damage to non-target species, as well as risks of water and soil contamination. Controls need to be designed around the morphology, phenology, and reproductive strategies of specific plants. For example, while prescribed fire will reduce invasions of conifers in native grasslands, it tends to stimulate growth and reproduction of many other invaders.

Recommended controls from various sources in the literature for the treatment of the primary invasive plants found on the Quabbin Reservoir watershed are listed in **Table 60.** The controls listed are not necessarily the methods proposed by the Division to address specific plant invasions. During FY2008, a Division-wide invasive plants plan will be developed that will include mapping and inventory methods, a strategy for detecting and eliminating new invasions, and the prioritization of treatments and controls for existing populations. In addition, the Division will hire two seasonal staff in the summer of 2007 to assist with invasive plant control.

Table 60: Major Invasive Plants on Quabbin Watershed and Conventional Control Measures

Invasive Species	Control[1]
Norway maple	Cut mature trees as close to base as possible. Pull seedlings/saplings including as much of the root as possible.
Japanese barberry	Pull young plants when ground is moist, and remove all root fragments. Repeated mowing can eliminate small populations. Mist apply 2% glyphosphate mixed with water and surfactant early in the season to cover plant, or apply 25% triclopyr directly to the outer 20% of cut stumps.
Japanese knotweed	Hand pull or grub plants, removing all fragments to prevent resprouting. Cut stems 2" above ground and immediately apply 25% solution of glyphosphate or triclopyr to cut stems. Follow with foliar spray of 2% glyphosphate or triclopyr with 0.5% non-ionic surfactant applied when outside temperatures are 65 degrees F or warmer, to control juvenile regeneration.
Oriental bittersweet	Regular mowing of edges and open areas will exclude bittersweet. Triclopyr herbicides are effective as foliar or basal applications.
Buckthorns	Seedlings are easily pulled. Larger stems can be pulled or cut, and may be killed by repeated fire. Freshly cut stumps should be treated with a 50% solution of glyphosphate to prevent resprouting. As buckthorns enter dormancy later than most species, treatments should be applied mid to late autumn to reduce risk to non-target species.
Honeysuckles	Hand-pulling is effective for isolated shrubs less than 3 years old. Most effective control of larger populations occurs through cutting and basal application of 20% glyphosphate. Seeds are not long-lived, so returning to remove seedlings by hand every two years or so should eliminate the population in time. Repeated burning is only effective for a short time, as the shrubs continue to resprout indefinitely following fire.
Olives	Repeated cutting of mature stems and sprouts and pulling of new seedlings may be effective. Best control is achieved by cutting followed by either burial or herbicide treatment of cut stump.
Multiflora rose	Regular mowing, where feasible, will remove this plant. Larger shrubs should be pulled or dug out. Where mowing is not practical, cutting followed by stump treatment with glyphosphate to prevent resprouting, is effective.

[1] Control measures are from current literature but are <u>NOT</u> DWSP policy at this time.

5.5.5.3.1 MA Invasive Plants Advisory Group: Strategic Recommendations for MA

In February of 2005, the Massachusetts Invasive Plants Advisory Group, an ad hoc committee of private and public organizations brought together in 1999 to address invasive plant issues in Massachusetts, produced its *Strategic Recommendations for Managing Invasive Plants in Massachusetts*. These recommendations were intended to provide guidance to landowners, public and private, seeking to

address the issue of invasive plants in an effective and efficient manner. The document includes the following nine principle recommendations:

1. Massachusetts should develop and implement a strategic management plan based on the recommendations of the MIPAG and integrated with the existing Massachusetts Aquatic Invasive Species Management Plan to address introduced invasive plant species.

2. A strategic management plan for managing invasive plants in Massachusetts should include a scientifically objective assessment process; a system for early detection and rapid response; criteria for setting research, management and education priorities; and develop broad public and private partnerships integrating efforts from the local to national scales.

3. Massachusetts should adopt the MIPAG criteria for invasive plant assessment and recognize the list of plant species determined by this process to be Invasive, Likely Invasive or Potentially Invasive within the Commonwealth. It should maintain an ongoing, transparent assessment process using the MIPAG criteria and with the participation of both public and private interest groups. This assessment should inform invasive species management strategies. Prevention strategies should predominantly focus on species assessed as Potentially Invasive and controlling the spread of Invasive species into priority conservation areas. Candidate species for eradication strategies should be selected from among those assessed as Likely Invasive.

4. Massachusetts should establish and support a centralized means within state government for inter-agency coordination on invasive species management, in partnership with public and private sector interests. This mechanism should facilitate the production of a strategic management plan for invasive plant species in the Commonwealth based on MIPAG's recommendations. It should help coordinate invasive species management efforts within the Commonwealth and integrate efforts with regional and national partners.

5. Massachusetts should establish and support an effective early detection and rapid response system for invasive species that is well integrated with regional and national efforts.

6. Massachusetts should assign to a responsible entity the task of assessing invasive species research needs and priorities for Massachusetts. It should integrate the work of public and private research partners, actively develop sources of funding for this research, and maintain a centralized database of this research in easily accessible form and linked to regional or national databases of this type. Funding sources for needed research should be developed and promoted.

7. A strategic management plan for invasive species in Massachusetts should set priorities for prevention, control, eradication and restoration efforts. Prevention should emphasize an early detection and rapid response system for new invasions and education about best management and prevention practices directed at the primary vectors for spreading invasive plant material. Except where eradication is feasible, control efforts should always manage toward a desired status or outcome for conservation resources compromised by invasive plant species, rather than the invasive species itself. Priority areas for management should be determined by identifying at all scales the natural and cultural resources at risk from invasive species and conducting baseline assessments of invasive species at those sites.

8. Massachusetts should adopt a policy of targeted outreach and education to raise awareness of the extent of the invasive plant problem and of the importance of each of our roles in preventing and controlling invasive species. Public education should focus on those vectors of spread most likely to introduce invasive plants into priority areas. The Commonwealth should endorse and adopt the voluntary protocols established under the Saint Louis Declaration for all government agencies, and promote their adoption by nursery professionals, landscape architects, the

gardening public, and botanic gardens and arboreta in Massachusetts. Specifically, the Commonwealth should prohibit state agencies from purchasing or intentionally introducing species determined to be Invasive, Likely Invasive, or Potentially Invasive through the scientifically objective assessment process of the MIPAG. Commercial industries should adopt a carefully constructed phase-out of these species in the trade while accommodating the economics of current inventories and existing contracts. Education and outreach described herein should be sufficiently funded and implemented assertively in order to steadily reduce the consumer demand for these species.

9. Public and private partnerships should be endorsed and strengthened as part of a strategic management plan for invasive plants in Massachusetts. The transparent, collaborative work of the MIPAG should be encouraged and supported as the means of assessing invasive species for the Commonwealth. Regional and national Partnerships and sources of funding for invasive plant management should be promoted and integrated into invasives management efforts in Massachusetts.

5.6 Protection of Cultural Resources

Forest management activities may be detrimental to archaeological resources without appropriate controls. Modern harvesting methods employ a wide range of heavy machinery, some of which, because of weight distribution and/or tire characteristics, can do irreparable damage to prehistoric or historic sites. Skidding logs can further disturb the soil. Operations may entail clearing areas for landings, turn-a-rounds, and access roads. Archaeological sites that lie closest to the surface can be obliterated by such activities. It is these same type of sites – those that are the youngest in time (i.e., the Early, Middle and Late Woodland) – that were most susceptible to destruction by the plow of the local farmer, and thus represent a relatively scarce piece of the archaeological record.

Accordingly, the DCR Archaeologist is one of several specialists who review proposed silvicultural operations during the annual internal review process. The Archaeologist specifically evaluates and assesses the impacts that harvesting could potentially have on archaeological resources that exist at any given site.

5.6.1 Silviculture and Cultural Resource Management: Prehistoric Sites

Management Objective: DWSP will minimize ground disturbance during a harvest in order to protect archaeological resources.

Recommended Practices for Highly Sensitive Areas:

- The harvest should occur during the winter with frozen soil conditions.
- Skidding should not be permitted.
- A small, tracked, excavator platform feller buncher, with its long reach and weight distributing tracks, is best suited for these sensitive areas.
- Wheeled feller bunchers, with limited reach and high ground pressures, should not be employed.

Recommended Practices for Moderately Sensitive Areas:

- One or more of the Highly Sensitive Area restrictions will be recommended.

In advance of any silviculture operation (also known as harvesting lots) on a site, Quabbin foresters submit a detailed Lot Proposal and 1:12,000-scale map for simultaneous in-house and public review.* The proposal describes the purpose for prescribed silvicultural treatment for an individual lot. It includes detailed site-specific information: overstory and understory vegetation, local forest composition and condition, topography and soils, wetlands and wildlife, etc., as well as Environmental Quality and Engineering considerations and harvesting limitations such as the type of machinery required to protect the soils and residual vegetation. All cultural resources known to the foresters are identified: foundations, cellar holes, walls, wells, dams, and prehistoric sites.

Lot Proposals and the associated maps provide the basis for Impact Assessment for the DCR Archaeologist. Site visits are sometimes required in order to assess microenvironment and features not reflected on the 1:25,000-scale USGS basemaps. The primary analytical tool is a predictive model of prehistoric site potential, based on Site Location Criteria.

Archaeologists have analyzed the environmental characteristics of thousands of sites throughout New England, and have identified a number of topographical variables that are consistently associated with

* The Lot Proposals for each fiscal year are available to the public at the Quabbin Visitor Center in Belchertown and at the Swift River Valley Historical Society in New Salem.

prehistoric sites. These Site Location Criteria are the basis of the predictive model used by the DCR Archaeologist to assess the likelihood of prehistoric significance at any given location.

The most important criteria for determining the archaeological sensitivity of a lot are: slope < 5 - 7 degrees; the presence of well-drained soils; and the prehistoric availability of fresh water within 1,000 feet. Other variables that may also be factors include: aspect, available lithic sources (stone for toolmaking), and elevation above sea level. When one or more of these variables are met, a site is considered to have been an attractive location for Native American habitation or subsistence activities. Such sites are classified as *highly sensitive* or *moderately sensitive* for prehistoric archaeological resources.

5.6.2 Silviculture and Cultural Resource Management: Historic Sites

Management Objective: DWSP will undertake vegetation management on historic sites which are particularly vulnerable and significant, as determined on a case-by-case basis. Careful removal of brush, saplings and trees is typically labor-intensive and must be repeated as resprouting and new growth occurs.

Recommended Practices:

- Remove most small to medium sized brush, saplings and trees from on and within historical features ,such as cellar holes and their foundation walls, channelized stream beds, mill dams, and historic buildings.
- Remove vegetation by cutting as close to the ground as feasible. Vegetation should not be pulled, or otherwise dislodged in a manner that would affect root systems.
- A small, tracked, excavator platform feller buncher may be appropriate for tree removal in some cases where the terrain is sufficiently level and stable. This machine has a long reach which limits the need to bring equipment too close to the structure; it picks the tree up, so there is no concern about the direction of the fall; and the tracks tend to distribute the weight, thereby limiting soil compaction.

Some cultural resources on the Quabbin watershed are protected at least in part by overall management and access strategies (see Landscape and Landscape Features, section 2.7.3 above). Others are more vulnerable and may require direct management efforts.

Vegetation, if left to grow unchecked in and around stone foundations, dams, raceways, etc., may compromise and ultimately destroy these archaeological features. The control of vegetation growth in and around archaeological sites and historic structures may therefore be a high priority at some sites.

Dana Common: Past and Present

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